The

Sailor's Handy Book

and

Yachtsman's Manual

E. F. Qualtrough U.S.N.

Theo. Jewett Eastman.

1895

THE SAILOR'S HANDY BOOK AND YACHTSMAN'S MANUAL

ADAPTED FOR THE USE OF

THE NAVY, MERCHANT SERVICE, REVENUE MARINE, AND YACHTSMEN

BY

E. F. QUALTROUGH

MASTER, U. S. NAVY

WITH ILLUSTRATIONS AND DIAGRAMS

NEW YORK
CHARLES SCRIBNER'S SONS
1892

TROW'S
PRINTING AND BOOKBINDING COMPANY,
NEW YORK.

PREFACE.

IN "THE SAILOR'S HAND-BOOK" I have endeavored to bring together such practical rules, useful tables, and general information as are constantly required by seafaring men.

The work is primarily intended for American seamen, and I have kept the wants of the United States Navy and of our Merchant Marine and Yachtsmen steadily in view.

I am indebted to MR. GEORGE W. BAIRD, United States Navy, for the Section on the Marine Steam-Engine. Its valuable practical information will be acceptable to the modern officer, who must be at once sailor and engineer.

By the kindness of CAPT. BEDFORD, Royal Navy, I have been enabled to utilize the contents of that valuable work "The Sailor's Pocket-Book," and, in availing myself of this courtesy, I have endeavored, as far as practicable, to preserve his admirable arrangement of such of the matter as is common to the two works.

The Abstracts of the Pilot Laws and the Rates of Pilotage are now for the first time brought together from authentic sources.

Among the authorities consulted may be mentioned the following:

The publications of the Navy Department, Hydrographic Office, Coast Survey, Signal Service, Light-House Establishment, and Life-Saving Service; the works of Smith, Evans, and Johnson on Compasses; Maury, Raper, and Riddell on Navigation; Luce, Nares, Harris, Rosser, and Vanderdecken on Seamanship; and the writings of Clement Mackrow and W. H. White on Naval Architecture; the Revised Statutes of the Maritime States, Admiralty Manual of Scientific Inquiry, Naval Science, and the Transactions of the Institution of Naval Architects.

During the progress of the work I have been much encouraged by the practical advice of PROFESSOR EDWARD S. HOLDEN, and am under obligations to many of my brother officers and other friends for suggestions and criticisms while the work has been passing through the press.

E. F. Q.

WASHINGTON, June 20, 1881.

CONTENTS.

SECTION I.

SECTION II.

SECTION III.

SECTION IV.

SECTION V.

Section 1.

PILOTING, PILOTS, ETC.

ABSTRACT OF THE PILOT LAWS OF THE VARIOUS SEABOARD STATES, AND RATES OF PILOTAGE FOR THE PRINCIPAL PORTS.

RULE OF THE ROAD.
INTERNATIONAL STEERING AND SAILING REGULATIONS.
UNITED STATES REGULATIONS FOR INLAND WATERS.

INTERNATIONAL CODE OF SIGNALS.
SIGNALS FOR PILOTS.
SIGNALS OF DISTRESS, ETC.

WEATHER INTELLIGENCE FOR THE COASTS OF THE UNITED STATES AND GREAT BRITAIN.

PILOTING.

ONE of the most important duties in a sailor's profession is the piloting of the vessels committed to his charge.

To insure success in piloting, a thorough knowledge is required of the coast or locality on which the ship may be sailing, and as it frequently happens, in the absence of a local pilot, that the sailor has to depend upon himself, the methods and instruments by means of which such knowledge may be acquired should be made the serious study of the navigator. As such methods and instruments are easy of access, it only remains for the sailor, by constant practice, to acquire facility in understanding the former and handling the latter, remembering that the constant exercise of such duties, in the opportunities afforded by fair weather, will enable him to conduct his vessel with greater safety in foul weather.

MARINER'S COMPASS.—Special care should be given to the mariner's compass, which instrument, in these days of iron ship-building. should be well understood, its peculiar deviation carefully ascertained, and the changes in that deviation constantly watched.

THE ANCHOR AND CABLE, also important implements in piloting, should be always ready for use, and not be lost sight of as valuable auxiliaries until the vessel has fairly left the land.

THE LEAD.—Above all, the sailor's attention is earnestly called to that simple but important instrument, *the Lead;* the neglect of which may be said to have been the great cause of modern disasters to shipping. The lead, deep-sea as well as hand, should never be lost sight of, and the crew (and even passengers) made familiar with the method of "passing the line along," so as to obtain a deep-sea cast with as little delay as possible. The lead should always be armed, and the soundings and nature of the bottom obtained by each cast of the lead should be compared with that shown in the supposed position of the vessel on the chart. It should be borne in mind, when approaching the land, that even under the most favorable circumstances, the use of the lead is desirable; but when, from the state of the weather and absence of celestial observations, the ship's position is dependent on dead reckoning, *the lead becomes of*

primary importance, and its constant use indispensable to safe navigation.

In obtaining a deep-sea sounding a little delay may be incurred in "passing along the line," but the length of modern steam vessels gives great facility to the performance of this simple act of seamanship; the engines may be eased and bottom obtained, thus securing, at a very small expenditure of time, the safety of life and property.

THE BAROMETER AND THERMOMETER, observed conjointly, will enable the intelligent seaman to acquire a knowledge of wind and weather.

THE CHART should not only be always at hand, but also be thoroughly understood; and as considerable information is to be obtained from every mark delineated thereon, the necessary abbreviations should be so well comprehended that they may be read at sight. In fair weather the coast in sight should be watched with the chart, so that the sailor may become accustomed to recognize the land as drawn upon the chart, the various points being observed as the vessel moves along, and the changes in their appearance as seen from different aspects, carefully noted. Every light and buoy passed should be observed as to its position, character, and color, so that they may be known again when encountered under less favorable circumstances.

THE SEXTANT should be always at hand, as a means of obtaining the ship's position; obtaining sights in cloudy weather in mid-ocean is good practice for doing the same thing when nearing the land, and observations are more valuable. Sumner's method for fixing the ship's position should be thoroughly understood and often practised; and the position should also be frequently determined by means of stars observed north and south of the zenith. A good longitude may often be obtained by stars taken just before sunrise or just after sunset.

The protractor, dividers, and parallel rulers should always be found in the neighborhood of the chart.

THE TIDES AND CURRENTS will require serious attention, and as they are always considerably affected by the prevailing weather, constant watchfulness is required to enable the sailor to handle these

useful forces. The *log* should be regularly hove; or, if the patent log is used, it should be frequently observed; attention to the log, combined with good steerage, and obtaining the vessel's position by means of bearings, etc., being the methods by which the movements of the water can be understood. The *dead reckoning* should be carefully kept, and constant comparison made between the currents actually experienced and those noted upon the charts.

CORAL REEFS.—The secret of successful navigation among coral reefs, where the lead is of little use, is to sail or steam with the sun astern of the vessel, conning her from the masthead. The vicinity of coral reefs is sometimes indicated by what is known as "white water," but generally the reefs show as dark green patches.

THE RULE OF THE ROAD should be so thoroughly mastered that there would be no hesitation in the action to be taken in meeting or passing vessels, by night or day, whether under steam or sail. The sailor should be as familiar with these laws as he is with the points of his compass, so as to enable him to move his ship as instinctively as he moves his own body. Helmsmen should be often tried to ascertain that they are able to carry out correctly and quickly the important orders of "Port" and "Starboard." The state of the bow lights as well as that of the masthead lights should be the constant care, not only of the officer of the deck, but also of the lookout man. The steam-whistle, or fog-horn of a sailing vessel, should always be in a state of efficiency in case of a vessel encountering a fog, during which time the sailor's vigilance should be increased, and arrangements made for rapid and instant action on meeting or passing another vessel. Speed must be considerably reduced, boats must be ready for lowering, and every preparation made to prevent loss of life in one of the most serious difficulties that has to be overcome at sea.

PILOTS.

IN the United States an act of Congress authorizes the several States to make their own pilotage laws, and such laws have accordingly been enacted by all the seaboard States.

While the pilot is on board, the power of the master of the vessel is not wholly superseded. It is his duty, in case of obvious and

certain disability or dangerous ignorance, to dispossess the pilot of his authority. It is also the duty of the master to see that a lookout is kept, and generally, while the orders of the pilot are imperative as to the course the vessel is to pursue, the command is still in the hands of the master.

The duty of a pilot, as soon as he boards a vessel, is to report himself to the master, make inquiries as to the condition of the anchors and cables, and see that a leadsman is at hand and signals ready for use. He should inform the master when he is ready to direct the piloting of the vessel, which, if the master wishes, may be as soon as he arrives on board; but the New York Pilot Commissioners prefer that the master keep control until within fifteen miles of Sandy Hook Light, as the pilots often board vessels 350 miles at sea, and the masters are supposed to be better navigators, and to know the qualities of their vessels better than the pilots do.

If the master does not at once give the pilot charge of the vessel, the latter should observe how the vessel minds her helm, steams or sails, and, when desired to do so, assist the captain with his advice.

The pilot should be a good seaman, but, as before remarked, the master is not relieved of his responsibility even after the pilot takes the direction of the vessel. He takes the orders from the pilot whether to go fast or slow if under steam; if under canvas, to make or reduce sail, and sees that they are executed.

The duty of the pilot, strictly, is to keep her in the channel-way, and conduct her safely to her anchorage or dock. To avoid dispute, he should always be informed by the master whether he is required to remain on board the vessel after she is anchored.

United States Naval Vessels.

THE employment of pilots by naval vessels is regulated by the Navy Department, and the present custom is clearly set forth in the following:

GENERAL ORDER No. 254.

NAVY DEPARTMENT,
WASHINGTON, September 2, 1880.

Coast pilots will not be employed on any vessel of the Navy unless authorized by the Bureau of Navigation; and when coast pilots are allowed, they shall not be paid for local pilotage.

When any vessel of the Navy shall require a local pilot in the waters of any State, a pilot licensed under the laws of the United States, or one licensed under the State

laws. shall be employed. But vessels of the Navy may enter and depart from ports within the waters of any State without United States or State pilots, at the discretion of the commanding officers thereof. In all cases, pilotage of any such vessels will be regulated in accordance with the existing laws of the States, respectively, wherein local pilots may be employed.

The Circular issued by the Department, May 14, 1874, in relation to the employment of pilots, is hereby rescinded.

R. W. THOMPSON,
Secretary of the Navy.

ABSTRACT OF THE PILOT LAWS OF THE MARITIME STATES, AND RATES OF PILOTAGE FOR VARIOUS PORTS.

MAINE.

PILOTS are appointed by the governor and council upon the recommendation of a majority of the ship owners and masters in the port for which they are appointed. Bonds are required to the amount of $5,000 for the faithful discharge of the duties, and the pilots are liable for all damages arising from neglect or incompetency on their part. Any master may pilot his own vessel.

Addison.—*Pilotage*, $5 to $10 per vessel.

Bangor.—*Pilotage*, $1.50 per foot of draught.

Bath.—*Pilotage*, from $5 to $10 for small vessels, and from $10 to $25 for ships.

Outward pilotage, $5 for small vessels and $10 to $15 for ships.

Biddeford.—*Pilotage*, $1.50 per foot of draught.

Portland.—*Pilotage*, as per agreement, usually $2.50 per foot from outside Cod Ledge, and $2 per foot from outside Trundy's Reef.

Rockport.—*Pilotage*, as per agreement, generally from $5 to $10.

Saco.—*Pilotage*, $1.50 per foot of draught.

Ship Island Harbor.—*Pilotage* for vessels drawing over eight feet

of water, $3 per foot. Steamers or vessels carrying United States mails pay half pilotage.

Detention, $5 per day.

Thomaston.—*Pilotage*, $5 to $10 for small vessels, and $10 to $15 for large vessels.

Yarmouth.—*Pilotage*, inward, $1 per foot of draught; outward, 50 cents per foot.

NEW HAMPSHIRE.

The manner of appointing pilots is the same as in Maine. Pilots are required to take charge of all vessels drawing over nine feet of water, except coasters. Bonds for the amount of $1,000 are required for the faithful performance of duty. Vessels inward bound must pay half pilotage if the services of a pilot are declined, but masters may pilot their own vessels when outward bound. If an inward bound vessel gets within the lighthouse before a pilot offers, no pilotage is due unless a pilot is actually employed.

Portsmouth.—*Pilotage* as per agreement.

MASSACHUSETTS.

The governor appoints pilots, except for the ports of Boston and New Bedford, where the appointing power is vested in commissioners. Bonds are required to the amount of $2,000 for the faithful performance of duty.

Pilot-boats cruise off Cape Cod, and inward bound vessels can generally get pilots there. All vessels, regardless of size, are exempt from pilotage when under coasting license. Vessels under 200 tons, sailing under a register, may decline the services of a pilot and pay half pilotage.

If no pilot offers before a vessel has arrived within the following limits, viz., within the chops of the harbors of Salem, Marblehead, or Gloucester; within the garnet of Plymouth Harbor, or within the bar of any barrel harbor, or within the entrance of Boston Harbor (*being a line drawn from Harding Rocks to the outer Graves and thence to Nahant Head*), the vessel is exempt from pilotage, unless a pilot is then employed, when two-thirds rates may be paid.

The Off-shore line is an imaginary line from Thatcher Island to

Monument land, Plymouth. Vessels inside of that line are clear of off-shore pilotage. The off-shore pilotage is compulsory only from November 1st to April 30th, inclusive.

Any pilot who brings a vessel in from sea is entitled to take her out when she next leaves port.

Rates of Pilotage for Boston.

Outward Rates.			Inward Rates.				
Draft in feet.	Rate per foot.	Amount.	Draft in feet.	Rate per foot.	Amount.	Off-shore pilotage.	Amount.
7	$1 65	$11 55	7	$2 64	$18 48	$3 70	$22 18
8	1 66	13 28	8	2 69	21 52	4 30	25 82
9	1 67	15 03	9	2 73	24 57	4 92	29 48
10	1 70	17 00	10	2 77	27 70	5 54	33 24
11	1 74	19 14	11	2 80	30 80	6 16	36 96
12	1 78	21 36	12	2 85	34 20	6 84	41 04
13	2 00	26 00	13	2 95	38 35	7 67	46 02
14	2 00	28 00	14	3 45	48 30	9 66	57 96
15	2 10	31 50	15	3 50	52 50	10 50	63 00
16	2 25	36 00	16	3 55	56 80	11 36	68 16
17	2 50	42 50	17	3 75	63 75	12 75	76 50
18	2 75	49 50	18	3 80	68 40	13 68	82 08
19	3 00	57 00	19	4 00	76 00	15 20	91 20
20	3 25	65 00	20	4 25	85 00	17 00	102 00
21	3 50	73 50	21	4 50	94 50	18 90	113 40
22	3 75	82 50	22	4 50	99 00	19 80	118 80
23	4 00	92 00	23	5 00	115 00	23 00	138 00
24	4 25	102 00	24	5 00	120 00	24 00	144 00
25	5 00	125 00	25	5 00	125 00	25 00	150 00

Chatham.—*Pilotage*, from $1.50 to $15.

Cohasset.—*Pilotage*, $3 per vessel.

Edgartown.—*Pilotage*, inward, $2 per foot of draught.

Fairhaven.—*Pilotage*, inward, $2.25 per foot of draught; outward, $1.85 per foot of draught.

Fall River.—*Pilotage*, $1.50 per foot of draught.

Gloucester.—*Pilotage*, the same as Boston rates.

Harwich Port.—*Pilotage*, $2 per foot.

Ipswich.—*Pilotage*, $1.50 per foot.

Marblehead.—*Pilotage*, over eleven feet draught, 67 cents per foot; from eleven to fifteen feet draught, 90 cents per foot; from fifteen to seventeen feet draught, $1.20 per foot; all over seventeen feet draught, $1.60 per foot.

Marion.—*Pilotage*, $2 per vessel.

Mattapoisett.—*Pilotage*, inward, $1 per foot of draught; outward, $2 per foot of draught.

Nahant.—*Pilotage*, $2 per foot draught.

Nantucket.—*Pilotage*, $1 per foot draught.

New Bedford.—*Pilotage*, $2.25 per foot draught.

Plymouth.—*Pilotage*, $1 per foot draught.

Provincetown.—*Pilotage*, inward, $2 per foot draught; outward, $1.50 per foot draught.

Quincey.—*Pilotage*, $1 per foot draught.

Salem.—*Pilotage*, $2.50 per foot draught.

Scituate.—*Pilotage*, $2 per foot draught.

Somerset.—*Pilotage*, from Fall River to Somerset, $2 per vessel; from Fall River to Dighton, 50 cents per foot draught.

Tarpaulin Cove.—*Pilotage*, to Boston, $4.25 per foot; to Wood's Hole, $1.07 per foot; to New Bedford, as per agreement.

Vineyard Haven (Holmes' Hole).—*Pilotage*, $1.25 per foot.

Wareham.—*Pilotage*, $5 to $10 per vessel.

Westport Point.—*Pilotage*, 50 to 60 cents per foot.

Wood's Hole.—*Pilotage*, $1.07 per foot in winter; 87 cents per foot in summer; outward pilotage one-third of inward rates.

RHODE ISLAND.

Pilots are appointed by commissioners. All vessels are required to take a pilot, or pay full pilotage, except steam vessels carrying a United States pilot, and coasting vessels, which are exempt unless

they actually employ a pilot. Vessels bound into Newport, Bristol, and Warren, are exempt from pilotage fees if no pilot offers before passing a line between Point Judith and Brenton's Reef Light-vessel.

East Greenwich.—*Pilotage*, per foot of draught, $1.25.

Newport.—*Pilotage*, per foot of draught, $1.25 to $3.50, inward, and 25 cents extra in winter; outward, $1 to $1.50 per foot.

Pawtuxet.—*Pilotage*, per vessel, $2.

Providence.—*Pilotage*, per foot of draught: Under 10½ feet, $1.25; 10½ to 12 feet, $1.50; 12½ to 14 feet, $1.75; 14½ to 16 feet, $2.25; 16½ to 18 feet, $2.75; over 18½ feet, $3.50.

Warren.—*Pilotage*, per foot of draught, $1.25.

Warwick.—*Pilotage*, per foot of draught, $1.25, summer; $1.75, winter.

Wickford.—*Pilotage*, per foot of draught, $1.25, inward; outward, half above rates.

CONNECTICUT.

The pilotage rates are established by the Superior Court of the county for waters within that county.

All vessels drawing over 9 feet of water, except coasters, fishing vessels and tug boats, are required to employ a pilot.

Bridgeport.—*Pilotage*, $1 per foot draught.

Greenwich.—*Pilotage*, $5 to $10 per vessel.

Milford.—*Pilotage*, about $3 per vessel.

Mystic.—*Pilotage*, 75 cents to $1 per foot draught.

New London.—*Pilotage*, $1 to $1.50 per foot.

Stonington.—*Pilotage*, $1 per foot draught.

NEW YORK.

Sandy Hook pilots are appointed and regulated by the Pilot Commissioners, who are chosen by the Underwriters and Chamber of Commerce.

Hell Gate pilots are appointed by the governor and regulated by the Port Wardens.

The pilot boats of New York and New Jersey cruise between Nantucket and Cape May, and it is recommended to masters of vessels, when boarded by a pilot, to enquire which State he belongs to, so as to know where to make complaint when necessary.

Port of New York.—When any vessel bound to the port of New York is boarded by a regular pilot, at such distance to the southward or eastward of Sandy Hook Lighthouse, that said lighthouse cannot be seen from the deck of such vessel in the daytime, and in fair weather, the addition of one-fourth to the regular pilotage rates shall be allowed to such pilot.

If the master desires the pilot to moor his vessel within Sandy Hook, or at Quarantine, instead of proceeding to the harbor of New York, the regular pilotage shall be allowed and the pilot shall be entitled to his discharge.

Between the first day of November and the first day of April, inclusive, $4 shall be added to the full pilotage of every vessel coming into, or going out of, the port of New York.

Masters of vessels shall give an account to the pilot of the draught of the vessel, and in case the draught is given less than the actual draught, are subject to a forfeit of $25.

A pilot boat on station is required to keep a Union jack at her foremast-head.

PILOTAGE FEES.—The fees for pilotage are established by law, as follows:

For every merchant vessel drawing less than fourteen feet of water, inward bound, $3.75 per foot.

For every vessel drawing fourteen feet and less than eighteen feet of water, $4.50 per foot.

For every vessel drawing eighteen feet and less than twenty-one feet of water, $5.50 per foot.

For vessels drawing twenty-one feet and upward, $6.50 per foot.

If any pilot shall be detained at Quarantine by the Health officer for being on board a sickly vessel as pilot, his necessary expenses of living, and $3 per day for every day of detention must be paid by the master or owners.

The pilotage on vessels, outward, shall be as follows:

Less than fourteen feet draught	$2 75	per foot.
Fourteen and less than eighteen feet draught	3 10	" "
Eighteen and less than twenty-one feet draught	4 10	" "
Twenty-one feet and upward	4 75	" "

For every day of detention in the harbor of an outward bound vessel, after the services of a pilot have been required and given, except the detention shall be caused by such adverse winds and weather that the vessel cannot get to sea; and for every day of detention of an inward bound vessel by ice, longer than two days for passage from sea to wharf, $3 shall be added to the pilotage.

Any pilot bringing in a vessel from sea shall, by himself or one of his boat's company, be entitled to pilot her to sea when she next leaves the port.

COASTERS.—Coasting vessels are not required to take a pilot, but if one be employed, full rates may be charged. Masters of large coasters may take out a license to pilot their own vessels.

RATES BETWEEN QUARANTINE AND THE CITY.—The pilotage for taking vessels from Lower Quarantine to New York is half the regular pilotage.

From Lower Quarantine to Upper Quarantine is one-fourth pilotage.

For taking vessels having had death or sickness on board, from the old to new Quarantine, double outward pilotage. Vessels from sickly ports, but having no sickness on board, single outward pilotage.

Pilots are required to board the nearest vessel having a signal flying for a pilot, or the vessel in most distress, under a penalty of $50.

A pilot boat, when in sight of a vessel wanting a pilot, shall, if there are no pilots on board, signalize the fact by running her flag or signal up and down twice, in the daytime; and at night by making a like signal with her masthead light.

Vessels returning from sea in consequence of head winds or stress of weather shall pay full pilotage.

A pilot is required to stay until notified by the master that his services are no longer wanted. The omission to give such notice entitles the pilot to "detention money."

Rates of Pilotage from April 1 to November 1.

Inward.					Outward.	
Draught.	Rate.	Pilotage.	Off-shore.	Total.	Rate.	Pilotage.
6 feet 0 inches..........	$3 75	$22 50	$5 62	$28 12	$2 70	$16 20
6 " 6 "	"	24 37	6 09	30 46	"	17 55
7 " 0 "	"	26 25	6 56	32 81	"	18 90
7 " 6 "	"	28 12	7 03	35 15	"	20 25
8 " 0 "	"	30 00	7 50	37 50	"	21 60
8 " 6 "	"	31 87	7 96	39 83	"	22 95
9 " 0 "	"	33 75	8 44	42 19	"	24 30
9 " 6 "	"	35 62	8 90	44 52	"	25 65
10 " 0 "	"	37 50	9 37	46 87	"	27 00
10 " 6 "	"	39 37	9 84	49 21	"	28 35
11 " 0 "	"	41 25	10 31	51 56	"	29 70
11 " 6 "	"	43 12	10 78	53 90	"	31 05
12 " 0 "	"	45 00	11 25	56 25	"	32 40
12 " 6 "	"	46 87	11 72	58 59	"	33 75
13 " 0 "	"	48 75	12 19	60 94	"	35 10
13 " 6 "	"	50 62	12 65	63 27	"	36 45
14 " 0 "	4 50	63 00	15 75	78 75	3 10	43 40
14 " 6 "	"	65 25	16 31	81 56	"	44 95
15 " 0 "	"	67 50	16 87	84 37	"	46 50
15 " 6 "	"	69 75	17 43	87 18	"	48 05
16 " 0 "	"	72 00	18 00	90 00	"	49 60
16 " 6 "	"	74 25	18 56	92 81	"	51 15
17 " 0 "	"	76 50	19 12	95 62	"	52 70
17 " 6 "	"	78 75	19 69	98 44	"	54 25
18 " 0 "	5 50	99 00	24 75	123 75	4 10	73 80
18 " 6 "	"	101 75	25 41	127 19	"	75 85
19 " 0 "	"	104 50	26 12	130 62	"	77 90
19 " 6 "	"	107 25	26 81	134 06	"	79 95
20 " 0 "	"	110 00	27 50	137 50	"	82 00
20 " 6 "	"	112 75	28 19	140 94	"	84 05
21 " 0 "	6 50	136 50	34 12	170 62	4 75	99 75
21 " 6 "	"	139 75	34 94	174 69	"	102 12
22 " 0 "	"	143 00	35 75	178 75	"	104 50
22 " 6 "	"	146 25	36 56	182 81	"	106 87
23 " 0 "	"	149 50	37 37	186 87	"	109 24
23 " 6 "	"	152 75	38 19	190 94	"	111 02
24 " 0 "	"	156 00	39 00	195 00	"	114 00
24 " 6 "	"	159 25	39 81	199 06	"	116 37
25 " 0 "	"	162 50	40 62	203 12	"	118 75

The rates of pilotage from November 1 *to April* 1 *are* $4, additional. Transportation, *North to East River and vice versa,* $5. Pilotage from Quarantine, one-quarter inward *pilotage, exclusive of off-shore.* Hauling to or from wharf, $3. Detention, $3 per day.

PILOTS FOR EAST RIVER, HELL GATE, ETC.—For piloting any vessel of the burden of ninety-five tons and upward, from the eastward of Sand's Point, or Execution Rocks, to the port of New York, or from the port of New York to Sand's Point or Execution Rocks, Hell Gate pilots may demand and receive $1.50 per foot for each foot of draught.

From the eastward of Hell Gate, to the port of New York, the rate is $1 per foot, for each foot of draught of water, and for outward pilotage the same.

Every pilot shall be entitled, in addition to the above rates, to demand and receive 25 cents per foot from any square-rigged vessel which they shall pilot to or from the port of New York.

A pilot who takes a vessel in is entitled to bring her out on the next outward voyage, if by way of Hell Gate.

From November 1st to April 1st, in every year, Hell Gate pilots shall be entitled to the sum of $2 from every square-rigged vessel, and to the sum of $1 from every schooner or sloop, in addition to the above rate of compensation.

In case any vessel shall make the usual signal for a pilot and shall then refuse to employ the pilot who shall first offer his services, half pilotage must be paid.

Any pilot who shall pilot any *Government vessel* through the said channel may demand the same compensation therefor as is now provided by law for like service in piloting such vessel to or from New York by way of Sandy Hook.

If any Hell Gate pilot shall render, upon the request of the master, any extra service for the preservation of a vessel while in distress, he shall be entitled to such amount as the Board of Wardens shall determine to be a reasonable reward; and, for every day of detention over twenty-four hours, he shall be entitled to $2.

North River.—The pilot who shall first board a vessel on the North River, coming from above Spuyten-Duyvel Creek, shall be entitled to the pilotage fees, provided said vessel takes a pilot. This rule applies also to vessels from Elizabethport, Newark, and Amboy.

In no case shall a pilot take charge of more than one vessel at a time.

Any pilot having *a vessel engaged* must report on board at least *twenty-four hours before the* time of sailing, or forfeit his claim.

Greenport.—*Pilotage,* $1.25 per foot.

New Rochelle.—*Pilotage,* from $8 to $12 per vessel. Local pilots can be obtained at City Island. Hell Gate pilots can be obtained at Execution Light.

Riverhead.—*Pilotage,* $5 per vessel.

NEW JERSEY.

Sandy Hook pilots for the ports of Jersey City, Newark, and Perth Amboy, are appointed by commissioners.

The regulations governing pilots do not differ materially from those governing New York pilots.

Atlantic City.—*Pilotage,* $5 to anchorage; $8 to city wharf.

Bridgeton.—*Pilotage,* $5 per vessel.

Somor's Point.—*Pilotage,* $1 per foot draught.

DELAWARE.

All vessels over seventy-five tons, engaged in trade between foreign ports, must employ a pilot.

If a pilot be declined, half pilotage from Philadelphia to the Capes of the Delaware must be paid, unless, in the case of an inward bound vessel, no pilot offers before she reaches Reedy Island; or in case of an outward bound vessel, that a pilot could not be had for twenty-four hours after the vessel was ready to leave.

It is the duty of the master of a vessel to report to the Collector the arrival or the intended departure of his vessel within thirty-six hours of such arrival, and before her departure, also the vessel's name, her draught of water at the time, and the name of the pilot who brought her in or who is to take her out.

New Castle. — Pilotage same as Philadelphia.

Wilmington. — Pilotage same as Philadelphia.

PENNSYLVANIA.

Pilots for Philadelphia are appointed by a Board of Wardens. There are three classes or grades of pilots licensed: the first is for vessels of any size or description; the second for vessels drawing

less than twelve feet of water; the third for vessels drawing under nine feet. New Jersey and Delaware pilots have power to act. The first qualified pilot that offers is entitled to take charge of the vessel, a second or third grade pilot may act if no first grade pilot offers before the vessel passes Reedy Island.

Philadelphia.—The pilotage is compulsory.

Rates of Pilotage, to and from the Capes of the Delaware.

Vessels drawing under twelve feet	$3 74	per foot draught.	
" " from twelve to fifteen feet,	4 16	"	"
" " " fifteen to eighteen..	4 50	"	"
" " " eighteen to twenty..	5 00	"	"
" " over twenty..............	5 50	"	"

Pilotage Table.

Draft.	Amount.	Draft.	Amount.	Draft.	Amount.
5 feet.	$18 70	12 feet.	$44 88	19 feet.	$95 00
5½ "	20 57	12½ "	52 00	19½ "	97 50
6 "	22 44	13 "	54 08	20 "	100 00
6½ "	24 31	13½ "	56 16	20½ "	112 75
7 "	26 18	14 "	58 24	21 "	115 50
7½ "	28 05	14½ "	60 32	21½ "	118 25
8 "	29 92	15 "	62 40	22 "	121 00
8½ "	31 79	15½ "	69 75	22½ "	123 75
9 "	33 66	16 "	72 00	23 "	126 50
9½ "	35 53	16½ "	74 25	23½ "	129 25
10 "	37 40	17 "	76 50	24 "	132 00
10½ "	39 27	17½ "	78 75	24½ "	134 75
11 "	41 14	18 "	81 00	25 "	137 50
11½ "	43 01	18½ "	92 50		

Detention, $3 per day.

From November 1st to April 1st, $10 additional must be paid for winter pilotage.

Vessels bound to the Breakwater may take or refuse a pilot; if one is employed, *one full* pilotage must be paid, and he may be detained or discharged.

If the vessel afterward proceeds to Philadelphia, one full pilotage must be paid, in addition to the sum already paid for pilotage into the Breakwater, but if the pilot has been detained, he shall receive pay for detention, and no additional pilotage for the Bay and River Delaware.

Vessels must remain at the Capes twenty-four hours, if necessary, to allow the pilot to be taken off. Every pilot carried to another port is entitled to his expenses home.

MARYLAND.

Pilots are appointed by a Board of Examiners, and their license, given each April or May, requires annual renewal. All vessels, except coasters, must take a pilot or pay full pilotage.

Masters of coasters are required to take out a license to navigate Chesapeake Bay without a pilot, which license is good for one year.

Pilots must take the nearest vessel to shore or the vessel in most distress.

Rates to Baltimore or from Baltimore to the Sea.—Vessels drawing fifteen feet or over, $5 per foot; twelve to fifteen feet, $4; less than twelve feet, $3.50. If the pilot be carried to sea he is entitled to receive $100 per month, in a vessel of over twelve feet draught; $80 in a vessel between nine and twelve feet; $66.66⅔ in a vessel drawing under nine feet; and is allowed, for every day of detention at Quarantine, $3 per day.

Pilots must keep three boats at sea. One on station fifteen miles north of Cape Henry; one on station fifteen miles south of Cape Henry; one in latitude of Cape Henry and ten miles distant.

VIRGINIA.

There is one pilot boat outside the Capes.

Pilots are appointed by a Board, and are divided into three classes. Those of the first class may pilot any vessel; those of the second class may pilot vessels whose draught does not exceed twelve feet; and pilots of the third class may pilot any vessel whose draught does not exceed nine feet.

All vessels (other than coasting vessels having a pilot license) inward bound must employ the first Virginia pilot who offers, Cape

Henry bearing west of south; and all such vessels outward bound must take the pilot who offers, west of Old Point Comfort. If a pilot be refused, full pilotage must be paid.

There is no obligation to take a pilot, if none offers until Cape Henry bears east of south.

Annual licenses may be granted to coasting vessels, and such licenses entitle the vessel to sail free without pilots to and from the sea; but all other coasters must pay regular pilotage. It is not necessary to take a pilot for points above Hampton Roads, Yorktown, Mobjact Bay, Urbana, or Smith's Point on the Potomac. Vessels coming from sea to Hampton Roads, and from thence to any port in Maryland, are subject to the same pilotage as vessels bound from Hampton Roads to sea; provided that for all steam vessels plying regularly between any Virginia port and any foreign port, a reduction of 50 cents per foot on the regular rates shall be made.

Pilots must take the first vessel of their class, or the vessel in most distress.

All vessels having a branch pilot must remain at the pilot station fifteen hours after arrival, if required, to give such pilot an opportunity to be taken off.

Every pilot must inquire as to the state of health of the vessels, and in case of infectious disease, or coming from an infected port, the vessel must follow his boat to quarantine. For this service the pilot is to receive $7 in addition to the regular pilotage fees.

Norfolk.—Rates of pilotage for vessels of war.

From sea to Hampton Roads, $3.35 per foot draught; from Hampton Roads to the Naval Anchorage, $3.35 per foot draught; from Naval Anchorage to Gosport Navy Yard, $20 per vessel. Outward pilotage the same as inward.

For every day a pilot is actually on board, $4. For every day of detention, to commence from the time notice is given to the pilot, $4.

Pilotage rates for merchant or other vessels. From sea to Hampton Roads, or the Compass Buoys, or Yorktown:

Vessels of less than twelve feet draught	$2 50 per foot.
" drawing from twelve to sixteen feet	3 15 " "
" " " sixteen to eighteen feet	3 85 " "
" " over eighteen feet of water	4 50 " "

If the vessel be boarded over twenty miles eastward of Cape Henry, 25 cents additional per foot draught. Foreign vessels not exempt by treaty with the United States one-fourth additional to above rates.

From Hampton Roads to Norfolk, or Portsmouth, or any intermediate place, 70 cents per foot draught.

From Hampton Roads to Jamestown, or any intermediate place, $1.95 per foot draught.

From Hampton Roads to Bermuda Hundred, or City Point, or any intermediate place, $2.65 per foot draught.

From Hampton Roads to Richmond, $3 per foot draught. From any of the said places outward, the same rates as inward. Any pilot detained on board any sea-going vessel must be paid $3 per day for such detention, and if carried to sea against his will, he is entitled to the sum of $300.

Potomac River.—Special pilots are appointed for the Potomac, who are bonded in the sum of $500, for the faithful performance of duty. Pilot Station—between Point Lookout and Ragged Point. Rates:—For vessels drawing under fifteen feet, $2 per foot; outward, $1.75 per foot. For vessels drawing over fifteen feet, $2.50 per foot; outward, $2.25 per foot. If no pilot is taken, half pilotage must be paid, unless under a coasting license for navigating the Potomac River.

Tappahannock.—*Pilotage*, up or down, $10 per vessel.

Yorktown.—*Pilotage*, $5 per vessel.

NORTH CAROLINA.

Pilots are appointed by commissioners for each port, and are divided into three classes.

A bond of $500 is required for the faithful performance of duty. Vessels refusing a pilot must pay full pilotage.

Beaufort.—*Pilotage* on vessels drawing from seven to ten feet, $1.50 per foot draught; from ten to thirteen feet draught, $2 per foot; over thirteen feet draught, $2.50 per foot.

Elizabeth City.—*Pilotage*, $8 per vessel over the bar.

New Berne.—*Pilotage*, vessels of 60 to 140 tons, across bar within limits of the pilot ground to Beacon Island Road, or Wallace's Channel, 10 cents per ton, and the further sum of 2½ cents for each ton over 140, and $2 for each vessel over either of the Swashes. For every vessel from mouth of Swash to New Berne, $1 per foot, and from same place to Edenton, $12, and to Elizabeth City, $10 per vessel. Outward rates the same.

Wilmington.—Rates of Pilotage for Cape Fear Bars and River.

Draught in feet.	Bars.	Smithville to Wilmington, and vice versa.	Five Fathom Hole to Wilmington, and vice versa.
6	$ 9 00	$ 9 50	$ 7 00
6½	9 75	10 50	8 00
7	10 75	12 00	9 00
7½	11 50	12 50	9 75
8	12 00	13 00	10 25
8½	12 75	13 50	10 75
9	13 50	14 00	11 25
9½	14 50	15 00	12 25
10	15 25	16 00	13 25
10½	17 00	18 00	14 50
11	18 50	19 75	15 75
11½	20 50	22 00	16 75
12	22 50	24 00	17 50
12½	25 50	26 50	20 00
13	28 50	29 00	22 25
13½	31 00	32 00	24 25
14	34 00	35 00	26 25
14½	38 00	40 00	28 25
15	42 00	44 00	30 00
15½	45 00		
16	50 00		
16½	55 00		
17	60 00		
17½	65 00		

From Smithville to Brunswick, or Brunswick to Wilmington, or vice versa, half regular pilotage rates.

From Smithville to Five Fathom Hole; from Five Fathom Hole to Brunswick; from Brunswick to Campbell's Island; from Campbell's Island to Wilmington; or vice versa, one-fourth rates.

SOUTH CAROLINA.

Pilots are appointed by commissioners. Vessels must pay full pilotage to the first pilot who offers, whether his services are accepted or not.

Any pilot who brings a vessel into port is entitled to carry her out.

Beaufort.—Rates of Pilotage for Port Royal and St. Helena Bars.

Draught in feet.	Amount.	Draught in feet.	Amount.	Draught in feet.	Amount.
6 (*and under*)	$18 00	14	$55 86	19½	$128 15
		14½	60 69	20	136 61
7	21 00	15	65 96	20½	145 38
8	24 00	15½	71 61	21	154 46
9	27 60	16	77 63	21½	163 35
10	31 30	16½	83 90	22	173 55
11	35 40	17	90 50	22½	183 56
12	40 00	17½	97 41	23	193 87
12½	43 50	18	104 63	23½	204 49
13	47 31	18½	112 16	24	251 42
13½	51 43	19	120 00		

Bar pilotage is charged only when vessels are boarded at sea and pilots carry them directly to their destination. When vessels cross the bar without a pilot, and take a pilot at the buoy inside the bar, half-pilotage is charged.

River Pilotage.

From Bay Point to Port Royal................	$15 00	per vessel.
" " " " Beaufort...................	20 00	" "
" Port Royal to "	10 00	" "
Beaufort or Port Royal to Savannah..........	25 00	" "
To shift moorings...........................	10 00	" "

Charlestown.— **Pilotage Rates.**

(*In and out the same.*)

Draught.	Amount.	Draught.	Amount.
6 feet, and under	$15 00	14 feet	$54 00
7 "	16 50	14½ "	60 00
8 "	18 50	15 "	66 00
9 "	21 00	15½ "	69 00
10 "	28 50	16 "	84 00
11 "	33 00	16½ "	100 00
12 "	40 00	17 "	120 00
12½ "	44 00	17½ "	150 00
13 "	45 00	18 "	180 00
13½ "	50 00		

Georgetown. — *Pilotage,* $2.75 per foot draught.

GEORGIA.

Pilots are appointed by commissioners at each of the ports of Savannah, Darien, Brunswick, and St. Mary's. Their jurisdiction is as follows:

SAVANNAH and the inlets north of Sapelo Bar;

DARIEN, Sapelo Bar and River Altamaha, also the bars and inlets south of Sapelo Bar as far as St. Simon's Bar.

BRUNSWICK.—St. Simon's Bar and Turtle River, also bars and inlets north of Great Satillo River;

ST. MARY'S, for bar of Great Satillo River, bar of St. Mary's and all bars and inlets between.

Bonds of $2,000 are required for the faithful performance of duty.

All vessels except coasters must employ a pilot.

Pilots must offer to the nearest vessel to the bar or the vessel in most distress. If a pilot is declined, full pilotage must be paid. It is the duty of a pilot, before entering a vessel, to make strict inquiry as to the state of health on board, and in case of any contagious, malignant, or infectious disease, the pilot is prohibited from boarding.

Any pilot bringing a vessel in has a right to take it out when ready for sea, or he may appoint a deputy to do so.

Pilots are expected to moor vessels.

Brunswick.—

Rates of Pilotage for St. Simon's Bar and Turtle River.

Foreign Vessels, not Exempt by Treaty, Fifty Per Cent. Additional.

Draught in feet.	Bar.	River.	Total.	Draught in feet.	Bar.	River.	Total.
6	$12 00	$6 00	$18 00	15	$44 00	$23 00	$67 00
6½	12 50	6 25	18 75	15½	48 00	24 00	72 00
7	13 50	6 75	20 25	16	51 00	25 50	76 50
7½	14 50	7 25	21 75	16½	54 00	27 00	81 00
8	15 00	7 50	22 50	17	58 00	29 00	87 00
8½	16 50	8 25	24 75	17½	61 00	30 50	91 50
9	18 00	9 00	27 00	18	64 00	32 00	96 00
9½	19 00	9 50	28 50	18½	67 00	33 50	100 50
10	20 00	10 00	30 00	19	70 00	35 50	105 50
10½	22 00	11 00	33 00	19½	75 00	37 50	112 50
11	24 00	12 00	36 00	20	78 00	39 00	117 00
11½	26 50	13 25	39 75	20½	82 00	41 00	123 00
12	29 00	14 50	43 50	21	86 00	43 00	129 00
12½	31 50	15 75	47 25	21½	90 00	45 00	135 00
13	34 00	17 00	51 00	22	95 00	47 50	142 50
13½	37 00	18 00	55 50	22½	110 00	55 00	165 00
14	40 00	20 00	60 00	23	130 00	65 00	195 00
14½	42 00	21 00	63 00				

Darien.—Bar pilotage is not due unless the vessel is boarded by a pilot beyond the bar; but any pilot bringing a vessel to safe anchorage within the bar shall receive half-pilotage. For detention to leeward of the bar, $3 per day. For detention at quarantine, $3 per day. For dropping vessels down the river to Doboy Island, or from the quarantine to ballast ground, or from ballast to loading ground, $7 for each drop, exclusive of the regular pilotage.

For every day of detention, after twenty-four hours' notice has been given by the master of the vessel, $3; provided the detention has been caused by said master.

It is the duty of pilots to assist in unmooring and preparing for sea.

In case a vessel uses a pilot-boat having no pilot on board, or another vessel on which there is a pilot as a guide in crossing the bar, half-pilotage must be paid the boat or pilot of guide vessel.

Rates of Pilotage.

Foreign Vessels, not Exempt by Treaty, Fifty Per Cent. Additional.

From Sea to Upper Buoy, or safe anchorage, and from Sapelo Bar to safe anchorage.				From Upper Buoy to Darien, or any other landing or place, and from a safe anchorage over Sapelo Bar up Sapelo River.			
Draught in feet.	Rate.	Draught in feet.	Rate.	Draught in feet.	Rate.	Draught in feet.	Rate.
6	$11 00	15	$41 00	6	$8 00	15	$30 00
7	12 00	15½	43 00	7	9 00	15½	31 00
8	13 00	16	46 00	8	10 00	16	33 00
9	16 00	16½	48 00	9	12 00	16½	34 00
10	18 00	17	52 00	10	13 00	17	37 00
11	21 00	17½	54 00	11	14 00	17½	39 00
12	23 00	18	58 00	12	19 00	18	41 00
12½	26 00	18½	60 00	12½	21 00	18½	43 00
13	31 00	19	64 00	13	23 00	19	46 00
13½	34 00	19½	67 00	13½	25 00	19½	48 00
14	35 00	20	70 00	14	26 00	20	49 00
14½	36 00			14½	27 00		

Drop, $7. Detention, $3 per day.

Savannah.—Pilots bringing a vessel from sea have the preference for carrying her up and down the river, and to sea again.

Savannah and Charleston packets are exempt from pilotage.

If a vessel follows a pilot-boat, or another vessel which has a pilot on board, over the bar or up to the city, half-pilotage must be paid to the boat or pilot of guide vessel.

Pilots delivering letters, or orders, on board of any vessel which shall touch off the Bar of Tybee for instructions, must be paid full Bar pilotage, in and out.

For every day of detention to leeward of the Bar, $4.32 per day, after the first twenty-four hours, provided the pilot boarded to leeward of the bar and not over thirty miles distant.

For detention at Quarantine, $4.32 per day.

Vessels requiring a pilot must give twenty-four hours' notice in writing in a book kept for that purpose.

Rates of Pilotage for Tybee Bar and River Savannah.

Foreign Vessels, not Exempt by Treaty, Fifty Per Cent. Additional.

Draught.	Bar and Cockspur pilotage.	Cockspur to Savannah.	Total.	Draught.	Bar and Cockspur Pilotage.	Cockspur to Savannah.	Total.
6	$12 09	$7 35	$19 44	15	$46 01	$27 71	$73 72
7	13 50	8 10	21 60	15½	48 60	29 22	77 82
8	14 79	8 97	23 76	16	51 30	30 78	82 08
9	18 26	11 04	29 30	16½	54 00	32 46	86 46
10	20 52	12 42	32 94	17	58 22	34 94	93 16
11	23 97	14 37	38 34	17½	61 02	36 72	97 74
12	28 95	17 49	46 44	18	64 05	38 55	102 60
12½	31 97	19 34	51 31	18½	67 17	40 34	107 51
13	35 21	21 23	56 44	19	71 72	43 04	114 76
13½	38 55	23 28	61 83	19½	74 96	44 99	119 95
14	39 86	23 87	63 73	20	78 30	46 98	125 28
14½	42 23	25 32	67 55				

For detention in town or river, after twenty-four hours' notice has been given, $4.32.

Drop from Town to Five Fathom	$10 80
" " Four Mile Point	12 96
" " Venus Point	17 28
" Venus Point to Tybee	17 28

All vessels bound up or down the river, and detained one tide, to pay the pilot a drop of $7.50, *but no detention for that day.*

If a vessel brings to in any part of the river to wait for a boat, or other transient purpose, detention must be paid.

St. Mary's.—*Pilotage* for vessels drawing under fourteen feet, $3 per foot draught. Over fourteen feet draught, $5 per foot.

FLORIDA

Pilots for each port are appointed by a Board of Commissioners for that port, or in some cases by the Board of Port Wardens. These Boards have power to remove pilots, and to establish rates and fees of pilotage. Special rates and regulations are established for each port.

Apalachicola.—Pilotage for vessels under ten feet draught, $3 per foot; from ten to fourteen feet draught, $4 per foot, and from fourteen to twenty feet draught, $5 per foot.

Cedar Keys.—*Pilotage*, $2 per foot draught, *compulsory*.

Fernandina.—*Pilotage compulsory.*

Vessels drawing	six to ten feet of water	$3 per foot.
" "	ten to fourteen feet of water	4 " "
" "	fourteen to eighteen feet of water	5 " "

Jacksonville.—The two pilot-boats are required to cruise outside the bar, weather permitting.

Each boat has its number on the mainsail, the Bettelini being No. 1, and the Nina No. 2.

A vessel calling off the bar for instructions must pay inward pilotage to the pilot who boards and communicates the instructions.

Any pilot who brings a vessel in has a right to take her to sea on her next trip.

Pilotage compulsory. Inward, $2.50 per foot draught; outward, $3 per foot draught; detention, $4.32 per day.

If a vessel follows a pilot boat over the bar, or up to the city, said boat shall be entitled to half-pilotage.

Key West.—All vessels entering or leaving the port of Key West, which do not require a pilot, must pay half-pilotage if spoken within the following limits: If approaching by main ship-channel: *outside the outer buoy.* By Hawks Channel; *with upper tower bearing nothing to the west of north.* By southwest channel; *nothing to eastward of Crawfish Key,* bearing north-northwest. By northwest channel; *outside the bar buoy.*

Any pilot who brings a vessel in is entitled to carry her out again.

Pilotage Rates.

For steamers or vessels drawing	six feet or less	$2 per foot draught.
" " " "	six to ten feet	3 " " "
" " " "	ten to fourteen	4 " " "
" " " "	fourteen to twenty	5 " " "
" " " "	over twenty	6 " " "

Detention, $5 per day.

Pensacola.— Pilotage Rates.

For vessels of under six feet draft	$2	per	foot.
" " drawing from six to ten feet	3	"	"
" " " " ten to fourteen	4	"	"
" " " " fourteen to twenty	5	"	"
" " " over twenty feet	6	"	"

If a pilot is declined, half-pilotage must be paid.

St. Augustine.—*Pilotage*, $3 per foot draught for all vessels drawing over six feet of water.

ALABAMA.

All pilots are licensed by the Harbor Master and Port Wardens. If vessels refuse a pilot, half-pilotage must be paid. Detention, $3 per day. If vessels cross one bar without a pilot, half-rates only are to be paid.

Bonds of $2,000 are required.

Mobile.— Pilotage Rates.

LOWER BAR.

Vessels drawing from four to ten feet	$3 50	per	foot.
" " " ten to twelve feet	4 00	"	"
" " " twelve to fourteen feet	4 50	"	"
" " " fourteen to twenty feet	6 00	"	"

UPPER BAR.

Rates, $2 per foot for all vessels.
Inward and outward rates the same.

MISSISSIPPI.

Pilots are appointed by commissioners for each port. Pilots must offer to the nearest vessel or the one in most distress.

Pilotage is compulsory.

Bonds for $1,000 are required.

Pascagoula.—*Pilotage*. $3 per foot. For piloting any vessel over the bar of Pascagoula River, and as far up as the railroad-bridge,

$5 additional; and from said bridge to the sawmills, the further sum of $5. Detention, $3 per day. If a pilot is carried to sea, he is entitled to $4 for every day that he is absent, and his board must also be furnished, unless after lying off the bar for *twenty-four* hours no boat appears to take him off.

Passage Christian.—*Pilotage*, $3 per foot.

Pearlington.—*Pilotage*, in and out, $20 per vessel.

LOUISIANA.

Pilots are appointed by the Harbor Master and Port Wardens of New Orleans. If the services of a pilot are not desired, half-pilotage must be paid.

New Orleans.— **Pilotage Rates.**

Vessels drawing under ten feet, $3.50 per foot.
Vessels drawing over ten feet, $4.50 per foot.
Vessels in tow do not pay river pilotage; if not in tow, $40 per vessel.
Tow-boats charge from sea to city and back to sea, 75 cents per ton

TEXAS.

Pilots are appointed by commissioners, and must give bonds for $5,000 for the faithful discharge of duty. Pilots for the Brazos River are appointed by the governor and confirmed by the Senate. If the services of a pilot be declined, half-pilotage must be paid.

Brazos Santiago.—*Pilotage*, $4 per foot.

Corpus Christi.—*Pilotage*, $4 per foot.

Galveston.—Pilots are on the lookout six miles outside the bar.

Pilotage, $4 per foot, both inward and outward.

When a vessel discharges and loads outside the bar, only one pilotage is due.

Indianola.—*Pilotage*, $4 per foot.

If a pilot speaks a vessel outside the bar, he can demand half-pilotage if not employed.

Port Laracca.—*Pilotage*, $3 per foot.

Sabine Pass.—*Pilotage*, for vessels of over 75 tons measurement, $3 per foot. If a pilot is declined, half-pilotage must be paid.

CALIFORNIA.

Pilots are appointed by commissioners, and are licensed for twelve months at a time.

The number allowed by law is twenty for the port of San Francisco, and two for the ports of Mare Island, Vallejo, and Benecia.

San Francisco.—Rates for all vessels under 500 tons, $5 per foot draught. Over 500 tons, $5 per foot and 4 cents per registered ton.

If the services of a pilot are refused, half-pilotage must be paid, unless the vessel is inside the bar before a pilot offers, in which case the above rates are reduced 50 per cent.

Whaling and *fishing* vessels are exempt from pilotage dues unless a pilot is actually employed. *Coasting* vessels are also exempt unless a pilot is employed.

Any vessel in tow of a steam-tug between the harbor of San Francisco and ports of Mare Island, Vallejo, or Benecia is exempt from pilotage unless a pilot is employed.

There are four pilot-boats at this port. The "off-shore" boat cruises near the Farrallones. One boat is on the inner station and one is cruising on the bar. The fourth boat is used as a "take-off" boat from outward bound vessels.

Any pilot who brings a vessel into the harbor of San Francisco is entitled to carry her out again when she is ready for sea.

Any pilot carried to sea or unnecessarily detained on board a vessel is entitled to $8 per day, not to exceed the sum of $1,000 in any one case.

Pilots are required to moor vessels.

Eureka.—*Pilotage*, if light, no charge; if loaded, 75 cents per ton; if with lumber, 75 cents per M.

San Diego.—*Pilotage*, not compulsory, $5 per foot draught, and 4 cents per ton additional on all vessels over 500 tons. Inward and outward rates the same.

OREGON.

Pilots are appointed by a board of commissioners.
Pilotage is compulsory.
Pilots carried to sea must be paid the salary of first officer.

Astoria.—*Pilotage*, $8 per foot draught under twelve feet; for each additional foot, $10. There are three tug-boats and one schooner having pilots on board.

Empire City.—*Pilotage*, $8 per vessel over bar; outward pilotago for loaded vessels, $1 per M for lumber, 50 cents per ton for coal.

Portland.—*Pilotage*, in and out. over the bar to Astoria, up to twelve feet draught, $8 per foot; for each additional foot, $10.
Up and down from Astoria, $4 per foot each way.

WASHINGTON TERRITORY.

Pilots are appointed by commissioners.
Bonds to the amount of $5,000 are required for the faithful performance of duty. If a pilot be refused, half-pilotage must be paid.

Port Townsend.—*Pilotage*, $8 per foot draught.

Tacoma.—*Pilotage*, $8 per foot draught.

THE RULE OF THE ROAD AT SEA.

THE *general* rule of the road for steamers is that in all ordinary cases two steamships meeting "end on or nearly end on," so as to involve risk of collision, shall port; that is to say, shall keep to the right, so that each may pass on the port (left) side of the other.

The *particular* rule of the road for steamers is, that if they are crossing, then the steamer that has another steamer on her own right-hand side shall get out of the way.

Steamships crossing so as to involve risk of collision, always show to each other a different colored light—green to red and red to green

—unless, therefore, a steamer sees another steamer's green light on her own port side, or another steamer's red light on her own starboard side, there is no danger so far as steamers crossing are concerned.

There are six cases in which it is your duty to alter course to avoid risk of collision—

1. *In a steamer, meeting a steamer end on or end nearly on.*
2. *In a steamer, nearing a sailing vessel.*
3. *In a steamer, approaching another on your starboard side.*

NOTE.—This is the case requiring the most caution and judgment.

4. *If under sail on the port tack, nearing a vessel under sail on the starboard tack.*
5. *If under sail going free, nearing a vessel under sail—close-hauled.*
6. *If under sail going free, and nearing another vessel to leeward—also going free.*

In the *first case only* is it right to *port* the helm without further consideration. In the other five cases, the course should not be altered until—either by bearings taken with an interval between them, or by bringing the vessel on with some part of the rigging, and watching whether she draws aft or forward—it is ascertained that the vessels are converging on one point, and *which is the best way to alter it*, to avoid collision.

One of the most fruitful causes of collision is, that the ship that has by the rules to alter course, does not do so promptly and sufficiently to show to the other ship clearly, and evidently, that she knows her duty and is performing it. When this is not done, the other ship is often led to adopt some wrong course to avoid collision, and thus bring it to pass. If under steam, a slight yaw with the helm will serve to show the direction you intend to take; if under sail and about to tack, let fly the jib-sheet; if to bear up, shiver the mizzen-topsail or brail up the spanker.

So long as you keep a Green Light opposed to a Green Light, or a Red Light opposed to a Red Light, no Collision can happen between passing Ships.

***The reckless use of* Port Helm leads to Collision.**

Aid to Memory, in Four Verses, by Thomas Gray.

1. TWO STEAMSHIPS MEETING.

When both side lights you see a-head,
Port your helm, and show your RED.

2. TWO STEAMSHIPS PASSING.

GREEN to GREEN, or RED to RED—
Perfect safety—Go ahead!

3. TWO STEAMSHIPS CROSSING.

NOTE.—This is the position of greatest danger: there is nothing for it but good look-out, caution, and judgment, with prompt action.

If to your Starboard RED appear,
It is your duty to keep clear;
To act as judgment says is proper;—
To Port—or Starboard—Back—or Stop her!

But, when upon your Port is seen
A steamer's Starboard light of GREEN,
There's not so much for you to do,
For GREEN to Port keeps clear of you.

4. ALL SHIPS MUST KEEP A GOOD LOOK-OUT, AND STEAMSHIPS MUST STOP AND GO ASTERN IF NECESSARY.

Both in safety and in doubt
Always keep a good Look-out;
In danger, with no room to turn,
Ease her!—Stop her!—Go astern!

INTERNATIONAL STEERING AND SAILING RULES.

Adopted by the various Maritime Nations to take effect on and after the First Day of September, 1880.

REGULATIONS FOR PREVENTING COLLISIONS AT SEA.

PRELIMINARY.

ART. 1.—In the following rules every steamship which is under sail and not under steam is to be considered a sailing ship; and every steamship which is under steam, whether under sail or not, is to be considered a ship under steam.

Rules Concerning Lights.

ART. 2.—The lights mentioned in the following articles, numbered 3, 4, 5, 6, 7, 8, 9, 10, and 11, and no others, shall be carried in all weathers, from sunset to sunrise.

ART. 3.—A seagoing steamship when under way shall carry:

(*a*.) ON OR IN FRONT OF THE FOREMAST, at a height above the hull of not less than twenty feet, and if the breadth of the ship exceeds twenty feet then at a height above the hull not less than such breadth, a bright white light, so constructed as to show an uniform and unbroken light over an arc of the horizon of twenty points of the compass; so fixed as to throw the light ten points on each side of the ship, viz., from right ahead to two points abaft the beam on either side; and of such a character as to be visible on a dark night, with a clear atmosphere, at a distance of at least five miles.

(*b*.) ON THE STARBOARD SIDE, a green light so constructed as to show an uniform and unbroken light over an arc of the horizon of ten points of the compass; so fixed as to throw the light from right ahead to two points abaft the beam on the starboard side; and of such a character as to be visible on a dark night, with a clear atmosphere, at a distance of at least two miles.

(*c*.) ON THE PORT SIDE, a red light, so constructed as to show an uniform and unbroken light over an arc of the horizon of ten points

of the compass; so fixed as to throw the light from right ahead to two points abaft the beam on the port side; and of such a character as to be visible on a dark night, with a clear atmosphere, at a distance of at least two miles.

(d.) The said green and red side lights shall be fitted with inboard screens projecting at least three feet forward from the light, so as to prevent these lights from being seen across the bow.

ART. 4.—A STEAMSHIP, when towing another ship, shall, in addition to her side lights, carry two bright white lights in a vertical line one over the other, not less than three feet apart, so as to distinguish her from other steamships. Each of these lights shall be of the same construction and character, and shall be carried in the same position as the white light which other steamships are required to carry.

ART. 5.—A SHIP, whether a steamship or a sailing ship, when employed either in laying or in picking up a telegraph cable, or which from any accident is not under command, shall at night carry in the same position as the white light which steamships are required to carry, and, if a steamship, in place of that light, three red lights in globular lanterns, each not less than ten inches in diameter, in a vertical line one over the other, not less than three feet apart; and shall by day carry in a vertical line over the other, not less than three feet apart, in front of, but not lower than, her foremast head, three black balls or shapes, each two feet in diameter.

These shapes and lights are to be taken by approaching ships as signals that the ship using them is not under command, and cannot therefore get out of the way.

The above ships, when not making any way through the water, shall not carry the side lights, but when making way shall carry them.

ART. 6.—A SAILING SHIP UNDER WAY, or being towed, shall carry the same lights as are provided by Article 3 for a steamship under way, with the exception of the white light, which she shall never carry.

ART. 7.—Whenever, as in the case of small vessels during bad weather, the green and red side lights cannot be fixed, these lights shall be kept on deck, on their respective sides of the vessel, ready

for use; and shall, on the approach of or to other vessels, be exhibited on their respective sides in sufficient time to prevent collision, in such manner as to make them most visible, and so that the green light shall not be seen on the port side, nor the red light on the starboard side.

To make the use of these portable lights more certain and easy, the lanterns containing them shall each be painted outside with the color of the light they respectively contain, and shall be provided with proper screens.

ART. 8.—A ship, whether a steamship or a sailing ship, when at anchor shall carry, where it can best be seen, but at a height not exceeding twenty feet above the hull, a white light, in a globular lantern of not less than eight inches in diameter, and so constructed as to show a clear, uniform, and unbroken light visible all round the horizon, at a distance of at least one mile.

ART. 9.—A pilot vessel, when engaged on her station on pilotage duty, shall not carry the light required for other vessels, but shall carry a white light at the mast-head, visible all round the horizon, and shall also exhibit a flare-up light or flare-up lights at short intervals, which shall never exceed fifteen minutes.

A pilot vessel, when not engaged on her station on pilotage duty, shall carry lights similar to those of other ships.

ART. 10. (*a.*)—Open fishing boats and other open boats when under way shall not be obliged to carry the side lights required for other vessels; but every such boat shall in lieu thereof have ready at hand a lantern with a green glass on the one side and a red glass on the other side; and on the approach of or to other vessels, such lantern shall be exhibited in sufficient time to prevent collision, so that the green light shall not be seen on the port side, nor the red light on the starboard side.

(*b.*) A fishing vessel, and an open boat, when at anchor, shall exhibit a bright white light.

(*c.*) A fishing vessel, when employed in drift net fishing, shall carry on one of her masts two red lights in a vertical line one over the other, not less than three feet apart.

(*d.*) A trawler at work shall carry on one of her masts two lights in a vertical line one over the other, not less than three feet apart,

the upper light red, and the lower green, and shall also either carry the side lights required for other vessels, or, if the side lights cannot be carried, have ready at hand the colored lights as provided in Article 7, or a lantern with a red and a green glass as described in paragraph (*a.*) of this article.

(*e.*) Fishing vessels and open boats shall not be prevented from using a flare-up in addition, if they desire to do so.

(*f.*) The lights mentioned in this article are substituted for those mentioned in the 12th, 13th, and 14th Articles of the Convention between France and England, scheduled to the British Sea Fisheries Act, 1868.

(*g.*) All lights required by this article, except side lights, shall be in globular lanterns so constructed as to show all round the horizon.

ART. 11.—A ship which is being overtaken by another shall show from her stern to such last-mentioned ship a white light or a flare-up light.

Sound Signals for Fog, etc.

ART. 12.—A steamship shall be provided with a steam-whistle or other efficient steam sound signal, so placed that the sound may not be intercepted by any obstructions, and with an efficient fog-horn to be sounded by a bellows or other mechanical means, and also with an efficient bell. A sailing ship shall be provided with a similar fog-horn and bell.

In fog, mist, or falling snow, whether by day or night, the signals described in this article shall be used as follows: that is to say,

(*a.*) A steamship under way shall make with her steam-whistle, or other steam sound signal, at intervals of not more than two minutes, a prolonged blast.

(*b.*) A sailing ship under way shall make with her fog-horn, at intervals of not more than two minutes, when on the starboard tack one blast, when on the port tack two blasts in succession, and when with the wind abaft the beam three blasts in succession.

(*c.*) A steamship and a sailing ship when not under way shall, at intervals of not more than two minutes, ring the bell.

Speed of Ships to be Moderate in Fog, etc.

ART. 13.—Every ship, whether a sailing ship or steamship, shall in a fog, mist, or falling snow, go at a moderate speed.

Steering and Sailing Rules.

ART. 14.—When two sailing ships are approaching one another, so as to involve risk of collision, one of them shall keep out of the way of the other as follows, viz.:

(*a.*) A ship which is running free shall keep out of the way of a ship which is close-hauled.

(*b.*) A ship which is close-hauled on the port tack shall keep out of the way of a ship which is close-hauled on the starboard tack.

(*c.*) When both are running free with the wind on different sides, the ship which has the wind on the port side shall keep out of the way of the other.

(*d.*) When both are running free with the wind on the same side, the ship which is to windward shall keep out of the way of the ship which is to leeward.

(*e.*) A ship which has the wind aft shall keep out of the way of the other ship.

ART. 15.—If two ships under steam are meeting end on, or nearly end on, so as to involve risk of collision, each shall alter her course to starboard, so that each may pass on the port side of the other.

This article only applies to cases where ships are meeting end on, or nearly end on, in such a manner as to involve risk of collision, and does not apply to two ships which must, if both keep on their respective courses, pass clear of each other.

The only cases to which it does apply are, when each of the two ships is end on, or nearly end on, to the other; in other words, to cases in which, by day, each ship sees the masts of the other in a line, or nearly in a line, with her own; and by night, to cases in which each ship is in such a position as to see both the side lights of the other.

It does not apply by day, to cases in which a ship sees another ahead crossing her own course; or by night, to cases where the red light of one ship is opposed to the red light of the other, or

where the green light of one ship is opposed to the green light of the other, or where a red light without a green light, or a green light without a red light, is seen ahead, or where both green and red lights are seen anywhere but ahead.

ART. 16.—If two ships under steam are crossing, so as to involve risk of collision, the ship which has the other on her own starboard side shall keep out of the way of the other.

ART. 17.—If two ships, one of which is a sailing ship, and the other a steamship, are proceeding in such directions as to involve risk of collision, the steamship shall keep out of the way of the sailing ship.

ART. 18.—Every steamship, when approaching another ship, so as to involve risk of collision, shall slacken her speed or stop and reverse, if necessary.

ART. 19.—In taking any course authorized or required by these regulations, a steamship under way may indicate that course to any other ship which she has in sight by the following signals on her steam-whistle, viz.:

One short blast to mean "I am directing my course to starboard."

Two short blasts to mean "I am directing my course to port."

Three short blasts to mean "I am going full speed astern."

The use of these signals is optional; but if they are used, the course of the ship must be in accordance with the signal made.

ART. 20.—Notwithstanding anything contained in any preceding article, every ship, whether a sailing ship or a steamship, overtaking any other, shall keep out of the way of the overtaken ship.

ART. 21.—In narrow channels every steamship shall, when it is safe and practicable, keep to that side of the fairway or mid-channel which lies on the starboard side of such ship.

ART. 22.—Where, by the above rules, one of two ships is to keep out of the way, the other shall keep her course.

ART. 23.—In obeying and construing these rules, due regard shall be had to all dangers of navigation; and to any special circumstances which may render a departure from the above rules necessary in order to avoid immediate danger.

No Ship, under any Circumstances, to neglect Proper Precautions.

ART. 24.—Nothing in these rules shall exonerate any ship, or the owner, or master, or crew thereof, from the consequences of any neglect to carry lights or signals, or of any neglect to keep a proper look-out, or of the neglect of any precaution which may be required by the ordinary practice of seamen, or by the special circumstances of the case.

Reservation of Rules for Harbors and Inland Navigation.

ART. 25.—Nothing in these rules shall interfere with the operation of a special rule, duly made by local authority, relative to the navigation of any harbor, river, or inland navigation.

Special Lights for Squadrons and Convoys.

ART. 26.—Nothing in these rules shall interfere with the operation of any special rules made by the government of any nation with respect to additional stations and signal lights for two or more ships of war or for ships sailing under convoy.

UNITED STATES.

RULES AND REGULATIONS FOR INLAND WATERS.

RULE I. — When steamers are approaching each other, the signal for passing shall be one sound of the steam-whistle to keep to the right, and two sounds of the steam-whistle to keep to the left.

These signals to be made first by the ascending steamer. If the dangers of navigation, darkness of the night, narrowness of the channel, or any other cause, render it necessary for the descending boat to take the other side, she can do so by making the necessary signals, and the ascending steamer must govern herself accordingly. These signals to be observed by all steamers, either day or night.

RULE II.—Should steamers be likely to pass near each other, and these signals should not be made and answered by the time such

boats shall have arrived at the distance of eight hundred yards from each other, the engines of both boats shall be stopped; or should the signal be given and not properly understood, from any cause whatever, both boats shall be backed until their headway shall be fully checked, and the engines shall not be again started ahead until the proper signals are made, answered, and understood.

RULE III.—When two boats are about to enter a narrow channel at the same time, the ascending boat shall be stopped below such channel until the descending boat shall have passed through it; but should two boats unavoidably meet in such a channel, then it shall be the duty of the pilot of the ascending boat to make the proper signals, and when answered by the descending boat to lie as close as possible to the side of the channel the exchange of signals may have determined, as allowed by Rule I., and either stop the engines or move them so as only to give the boat steerage way, and the pilot of the descending boat shall cause his boat to be worked slowly until he has passed the ascending boat.

RULE IV.—When a steamer is ascending and running close on a bar or shore, the pilot shall in no case attempt to cross the river when a descending boat shall be so near that it would be possible for a collision to ensue therefrom.

. . . .

RULE VI.—When any steamer, whether ascending or descending, is nearing a short bend or point where, from any cause, a steamer approaching in an opposite direction cannot be seen at a distance of six hundred yards, the pilot of such steamer, when he shall have arrived within six hundred yards of that bend or point, shall give a signal by one long sound of his steam-whistle as a notice to any steamer that may be approaching; and should there be any approaching steamer within hearing of such signal, it shall be the duty of the pilot thereof to answer such signal by one long blast of his steam-whistle, when both boats shall be navigated with the proper precautions, as required by preceding rules.

RULE VII.—When a steamer is running in a fog or thick weather, it shall be the *duty of the pilot to* sound his steam-whistle at intervals *not exceeding two minutes.*

RULE VIII.—When steamers are running in the same direction and the pilot of the boat which is astern shall desire to pass on either side of the boat ahead, he shall give the signal as in Rule I., and the pilot of the boat ahead shall answer by the same signal, and allow the other to pass on the side selected, and shall in no case attempt to cross her bow or crowd upon her course.

RULE IX.—When boats are moving from their dock or berth, and other boats are liable to pass from any direction toward them, they shall give the same signal as in case of boats meeting at a bend; but immediately after clearing the berth so as to be fully in sight, they shall be governed by Rule II.

RULE X.—Doubts or fears of misunderstanding signals may be expressed by several short sounds of the whistle in quick succession.

. . . .

RULE XVI.—Signal lights for steamers under way are provided by law as follows, the same to be carried between sunset and sunrise:

For ocean steamers and steamers carrying sail, a bright white light at the foremast head, to throw the light through ten points of the compass on each side of the ship, viz.: from right ahead to two points abaft the beam, and to be visible at least five miles. On the starboard side a green light, and on the port side a red light, each to throw the light through ten points of the compass on their respective sides, viz.: from right ahead to two points abaft the beam, and to be visible at least two miles. These colored lights are to be fitted with inboard screens, projecting at least three feet forward from the light to prevent them from being seen across the bow.

For steamers navigating waters flowing into the Gulf of Mexico, a red light on the outboard side of the port smoke-pipe, and a green light on the outboard side of the starboard smoke-pipe; these lights to show both forward and aft, and also abeam on their respective sides.

For coasting steamers and those navigating bays, lakes, or other inland waters, other than ferry-boats and those above provided for, the red and green side-lights as prescribed for ocean steamers, and a central range of two white lights, the after light being carried at an

elevation of at least fifteen feet above the light at the head of the vessel; the headlight to show through twenty points of the compass, viz.: from right ahead to two points abaft the beam, on either side of the vessel, and the after-light to show all around the horizon.

For steamers towing other vessels, the colored lights shall be the same as prescribed for ocean steamers; and two white masthead lights shall also be carried vertically to distinguish them from other steamers; the white light to show through twenty points of the compass, viz.: from right ahead to two points abaft the beam on either side of the vessel; white lights shall also be placed on the extreme outside of the bow on either hand, and also on the extreme after part of same.

RULE XVII.—A bright white light, not exceeding twenty feet above the hull, shall be exhibited by all steamers when at anchor, between sunset and sunrise, in a globular lantern of eight inches diameter, so placed as to show a good light all around the horizon.

Adopted by the Board of Supervising Inspectors, October 17, 1865.

THE INTERNATIONAL CODE OF SIGNALS.

THE INTERNATIONAL CODE OF SIGNALS FOR THE USE OF ALL NATIONS is that which, on its first publication, in 1857, was known as the *Commercial Code of Signals*. The more comprehensive title, "*International*," has been adopted, owing to the general acceptance of the Code by all maritime nations; and in order to facilitate the means of communication under every circumstance, whether between passing ships or between ships and signal stations placed along the coast, *translations* of the Code have been made by order of the different governments; and the Code itself has been so arranged that when, from distance or haze, colors cannot readily be distinguished, it may nevertheless be used under the form of Distance Signals, and by means of a Semaphoric System.

Code-Flags or Symbols.

The symbols of the International Code consist of eighteen flags, namely:

1 Burgee,
4 Pennants, and,
13 Square Flags,

representing the eighteen consonant letters of the alphabet, which are used as *ciphers* of the Code. There is also a "Code Pennant," which is used as the *Code Signal*, and also as the *Answering Signal* of the Code.

These flags, with their respective significations, are shown in the plate, and may be described as follows:

BURGEE.

B - - - - Red, swallow-tail.

PENNANTS.

C - - - - White, with red spot.
D - - - - Blue, with white spot.
F - - - - Red, with white spot.
G - - - - Yellow-blue, in two vertical stripes.

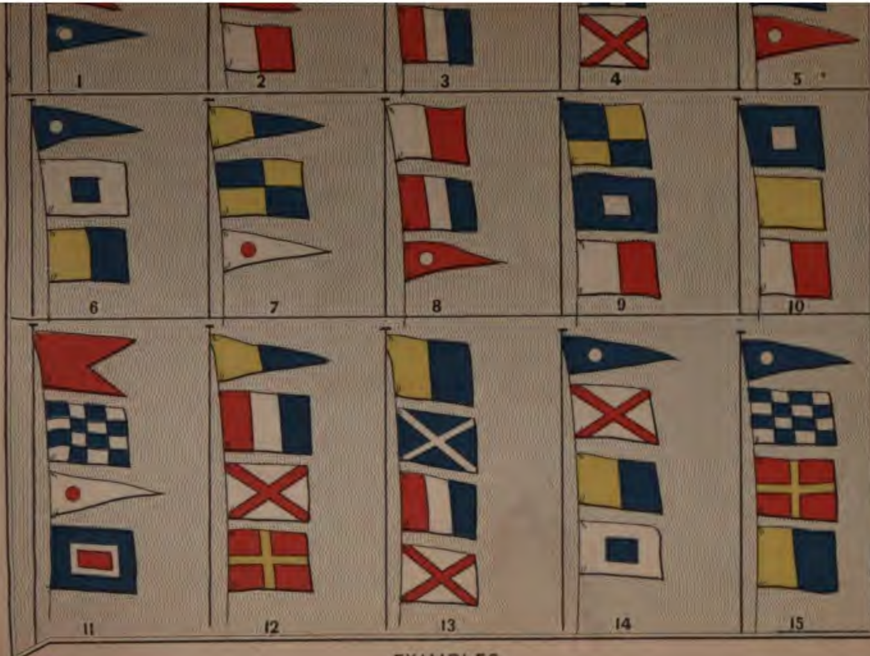
SQUARE FLAGS.

H - - - - White-red, in two vertical stripes.
J - - - - Blue-white-blue, in three horizontal stripes.
K - - - - Yellow-blue, in two vertical stripes.
L - - - - Blue and yellow, in four alternate checks.
M - - - - Blue, with white diagonal cross.
N - - - - Blue and white, in sixteen alternate checks.
P - - - - Blue, with white centre.
Q - - - - Yellow,—quarantine.
R - - - - Red, with yellow right cross.
S - - - - White, with blue centre.
T - - - - Red-white-blue, in three vertical stripes.
V - - - - White, with red diagonal cross.
W - - - - Blue-white-red, in three borders.

CODE PENNANT.

Code Signal - - - - Red and white, in five vertical stripes.
Used also as "Answering Signal."

FLAGS OF THE CODE.



EXAMPLES.

has been said that these flags represent certain letters of the ıbet, but it must be clearly understood that they do so, *not as ıbetical letters, whereby a word or set of words (to form a sentence) be spelt*, BUT *as arbitrary Signs or Symbols;* and hence, when a is made, whether of one flag, or by a combination of two, three, ır flags, certain words or even a completed sentence may be indi- l, which, by a previous arrangement (as through the Code Signal) can equally be understood by the mariners of all nations--since *ymbolic* flags, however combined, have the same significance in nguages.

e flags being known, the next step is to understand the *special distinctive character of the various Signals, as indicated by the ı of the Hoist and Upper Flag.*

Sea or in Harbor, before making a signal with flags, be sure to the *Ensign* with the Code Signal (Pennant) under at the Peak.

e flags making the signal should be hoisted at the masthead, ssible; or, otherwise, where best seen.

Distinctive Character of Signals.

A *single* flag, when used, may be the *Code* Pennant, the *White* ınt (C), or the *Blue* Pennant (D), and would have the following ications:

The *Code* Pennant is *also* the *Answering* Pennant.
The *White* Pennant (C) signifies *Yes:* (Affirmative).
The *Blue* Pennant (D) signifies *No:* (Negative).

t.—All the other Code Signals are made either with *two*, *three*, or *four* FLAGS *ist*, and the special *character* of the Signal is *indicated by the Upper Flag* of st.

Signals of TWO *Flags* with—

The *Burgee* uppermost, are *Attention* or *Demand* Signals.
A *Pennant* uppermost, are *Compass* Signals.*

---

e *Compass* Signals are given in points and half-points, and are *Correct Mag-* those ranging—

From North to E. ½ N. have the *white* pennant (C) uppermost.
From East to S. ½ E. have the *blue* pennant (D) uppermost.
From South to W. ½ S. have the *red* pennant (F) uppermost.
From West to N. ½ W. have the pennant G uppermost.

ɪr the same heading, each of these pennants with the Flag W *underneath* indi- *Meteorological Report.*

A *Square Flag* uppermost, are *Urgent*, *Danger*, or *Distress* Signals.*

3. Signals of THREE *Flags*,

are *General*,† and *relate to all ordinary subjects* of inquiry or communication appertaining to Ships and Shipping, Crew, Passengers, Cargo, Provisions, Books and Instruments of Navigation, Lights and Buoys, Soundings, Latitude, Longitude, Time, Weather, Winds, Money, Value, Quantity, Numbers, etc., etc.

4. Signals of FOUR *Flags* with—

The *Burgee* uppermost, are *Geographical Signals*.
The *Pennant* C, D, or F uppermost, are *Spelling* and *Vocabulary Signals*.
The *Pennant* G uppermost, are *names of Men-of-War*.
A *Square Flag* uppermost, are *names of Merchant Ships* and also of *Yachts*.

CAUTION.—The *Flags* to be *hoisted at one time, never exceed Four*.

NOTE.—Each Signal has throughout the Code but *one signification*; for, with the 18 Flags, no less than 78,642 different Signals can be made; hence the chief recommendations of the INTERNATIONAL CODE are *distinctiveness* and *comprehensiveness*.

---

* The *Urgent* Signals range from HB to SD, and the greater part of them are of the utmost importance wherever and whenever made; they relate to *distress*, *danger*, *caution*, *directions to a vessel under weigh or at anchor*, *fire*, *leak*, *various wants*, *need of assistance*, etc., etc. A vessel at sea passing in the direction of another flying any such signal should, if possible, immediately bear down toward her.

NC is the special distress signal according to Merchant Shipping Act, 1873.
PT " Pilot " " " " "

† Among the *General* Signals, those with Flag F, G, or H *uppermost*, chiefly relate to Latitude, Longitude, Time, Nautical Instruments and Books, Weather, Wind, Storm, Fog, Ice, and Sea.

EXAMPLES ILLUSTRATING THE FORM OF HOIST.

(*See Plate.*)

TWO-FLAG SIGNAL, WITH BURGEE UPPERMOST.

1. *Attention or Demand;* **B D** meaning "What ship is that?"
2. " " **B H** meaning "Vessels that wish to be reported all well, show your distinguishing Signals."

TWO-FLAG SIGNAL, WITH PENNANT UPPERMOST.

3. *Compass;* **G T** meaning North by West.

TWO-FLAG SIGNAL, WITH SQUARE FLAG UPPERMOST.

4. *Urgent, Danger,* or *Distress;* **N V** meaning "I am sinking."
5. " " " **P F** meaning "Want boats immediately."

THREE-FLAG SIGNAL.

6. *General;* **D S K** meaning "Do you come from any port putting you in quarantine?"
7. *General;* **G L C** meaning "When were your last observations for Latitude?"
8. *General;* **H T F** meaning "During the Monsoon."
9. *General;* **L P H** meaning "Will the soundings be a safe guide?"
10. *General;* **P Q H** meaning "Tell my owner ship answers remarkably well."

FOUR-FLAG SIGNAL, WITH BURGEE UPPERMOST.

11. *Geographical;* **B N C W** meaning "Moreton Bay."

FOUR-FLAG SIGNAL, WITH PENNANT G UPPERMOST.

12. *Man-of-War;* **G T V R** meaning "H. M. ship *Sultan.*"

FOUR-FLAG SIGNAL, WITH SQUARE FLAG UPPERMOST.

13. *Merchant Vessel;* **K M T V** meaning "The steamer *Baltic*, of Liverpool."

FOUR-FLAG SIGNAL, WITH PENNANT C, D, OR F UPPE

14. *Vocabulary;* **D V K S** meaning "The steamer is getti to come off to yo

15. *Vocabulary;* **D N R K** meaning "What is the premi surance?"

DISTANCE SIGNALS.

The *Colors* of the Code Flags may be rendered indistinct excessive distance; or, on the other hand, where the distan great, haze will equally interfere to mask the color, but not tl of a flag; in order, therefore, that no opportunity of com ing at sea should be lost, a system of Distance Signals are in to correspond with the Code Flags.

Also, for the purpose of facilitating communication, the *Signals*, *hoisted singly* and followed by "Stop," have a speci fication importing *urgency*.

The *characteristic* symbol of the Distance Code is the *I* Ball at least appearing in every hoist of the Distance Code; t symbols may be Pennants or Square Flags of any color.

The arrangement of these symbols in the Distance Signal shown, and it may be a help toward acquiring a knowledg various combinations by remembering that as regards the Balls in the various hoists—

The *first* column (**B** to **H**) contains all the combinations ha *Ball* or *Balls first* or *uppermost* in the hoist.

The *second* column (**J** to **P**) contains all the combination the *Ball* or *Balls*, *second* or *separated* in the hoist.

The *third* column (**Q** to **W**) contains all the combination the *Ball* or *Balls last* or *lowermost* in the hoist.

For the Distance Signals, an aid to memory may be put as

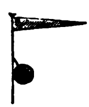
B to **F** have Ball at top;
G and **H** have 2 Balls at top;
J to **M** have Ball in middle;
N and **P** have Balls separated;
Q to **T** have Ball at bottom;
V and **W** have 2 Balls at bottom.

This being understood, with the letters arranged in 3 columns, the following is the distribution of the pennants and flags in each column:—Pennant and Square Flag; Square Flag and Pennant; 2 Pennants; 2 Square Flags; 1 Pennant; 1 Square Flag.

Significations of the Distance Signals when made *singly*, which will be indicated by the "*stop*" following each hoist.

B. Asks name of ship or Signal Station in sight.
C. Yes.
D. No.
F. Repeat Signal, or hoist it in a more conspicuous place.
G. Cannot distinguish your Flags. Come nearer, or make Distance Signals.
H. You may communicate by the Semaphore, if you please.
J. Stop, or bring to. Something important to communicate.
K. Have you any telegrams or dispatches for me?
L. Want a pilot. Can I have one?
M. Want a tug. Can I have one?
N. What is the Meteorological Weather Forecast?
P. Calls attention of Signal Station in sight.
Q. Vessel asks for orders by telegraph from owner, Mr. —— at ——.
R. Report me by telegraph to my owner, Mr. ——, at ——.
S. Send the following message by telegraph.
T. Send the following message by the *Signal Letters*, through the telegraph.

In addition to the above, the following Distance Signals, composed of *Two Symbols*, have the special signification indicated beneath.

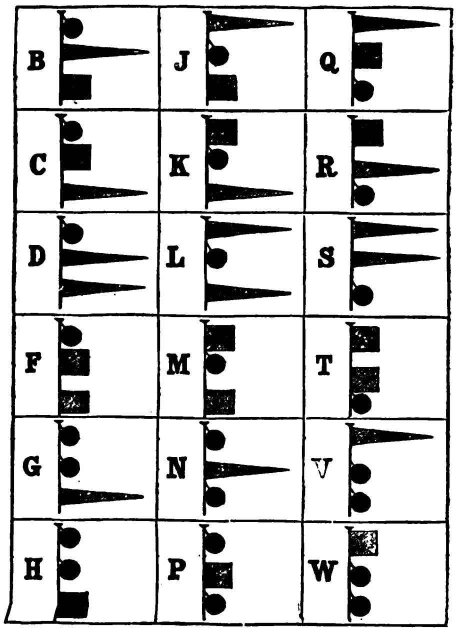
			
You are running into danger.	Fire: or Leak. Want immediate assistance.	Short of Provisions. Starving.	Aground. Want immediate assistance.

GENERAL ALPHABETICAL TABLE for Composing Distance :

Preparative  Answering

and also
Stop after each complete Signal.

Annul Signal.



Semaphore Signals.

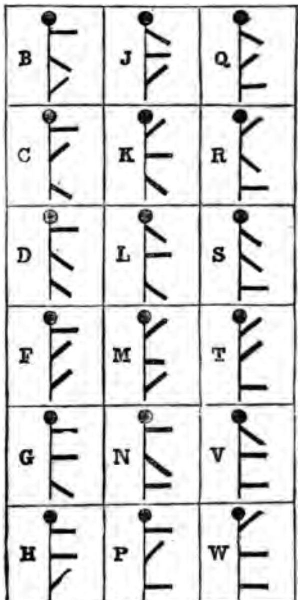
Semaphore masts are furnished with *Three Arms*, which are used as follows in the representation of any of the Distance Signals :—

1. The *Disk* at the *top of the mast* indicates that signals are being made by the *International Code*, and it must remain there whilst so signalling. It is a large *black disk with white rim*.

2. Any *arm* pointing *downward* represents a PENNANT.

3. Any *arm* in a *horizontal* position represents a BALL.

4. Any *arm* pointing *upward* represents a FLAG.



When the arms are *not working* they are not visible, but lie parallel *with the masts*.

The *Semaphore Signals* are always to be *read off as Distance Signals;* and a *single* Semaphore letter (or symbol) has the same signification as a Distance Signal when made *singly.*

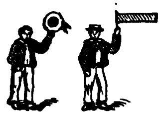
All communications between passing ships and the Semaphores are to be made *exclusively by the Signals of the International Code.*

Boat Signals.

The Symbols for Boat Signals are :--

1. Two *square* flags, or handkerchiefs, or pieces of cloth.
2. Two long strips of cloth, or parts of a plank, or pieces of wood longer than broad—(for pennants).
3. Two balls, or hats, or round bundles, or buckets.

With these any of the distance Signals can be made—holding the Symbol at Arm's length; and the Signal is to be *made from right to left* and *read from left to right,* thus :—



Equivalent to Ball above Pennant, or "You are Running into Danger."

J.

B.

Signifying "Accident; want a Surgeon."

"Stop;" or Finish after each complete signal.

In making Boat Signals it is important to use only the proper means to attract attention, and to avoid those that may occasion confusion or misinterpretation.

Signal Book.

In the Signal Book the Combinations of Flags forming the *entire series of Signals* from **B C** to **F G M D** *follow in consecutive order*, so that with very little trouble, and with ordinary intelligence, a Signal can be made or deciphered, as the case requires.

The book consists of several parts, but it is only necessary to explain Parts I. and II.

Part I. contains, in successive order—

The 2-Flag Signals, of which remember that those with Square Flag uppermost, *when made at sea*, should never be disregarded, as in all probability they may indicate *danger* or *distress*.

The 3-Flag Signals for *general communications* and *enquiries*, as between passing ships, or a ship and a shore station; to these succeed the *Numeral*, *Address*, and *Alphabetical* Tables; and, finally,

The 4-Flag Signals with Burgee uppermost, all of which are *Geographical*.

Part II. commences with

The Alphabetical Spelling Table, which is a 4-Flag Signal, and is followed by a

Vocabulary and Index to the Signals in Part I.; and *note* that the *arrangement* is, in this portion of the book, *alphabetical, after the manner of a Dictionary;* every Signal which has appeared in Part I. is inserted in its proper alphabetical order, with the *Signal Letters* placed *to the right.* But there are also many additional 4-Flag Signals which are not included in Part I., and for these the Signal Letters are placed to the left; they begin with **C H B D** and end with **F G M D.**

The Alphabetical Geographical Index closes Part II.

For MAKING A SIGNAL *reference should invariably be made to* Part II. of the Signal Book.

To INTERPRET OR READ A SIGNAL ***reference should be made to*** **Part I. of the Signal Book,** ***unless*** **it be a 4-Flag Signal other than a Geographical one, in which case it will be found in Part II. to the left of the column.**

But ***for a Ship's Name*** **reference must be made to the Code List for the year.**

Extracts of Danger or Distress Signals from Signal Book.

(*Those considered as most urgent.*)

Assistance.

H B. Want immediate assistance.
H D. No assistance can be rendered.
H F. We are coming to your assistance.

Boats.

H J. Boat, or life-boat cannot come.
H K. Boat in distress.
H L. Do not attempt to land in your own boats.
H M. Man overboard.

Communicate.

H P. Close; I have important intelligence.
H Q. Allow no person on board.

Damage or Accident.

H T. Damaged mast; cannot carry sail.
H V. Damaged rudder; cannot steer.
H W. Machinery disabled.
J B. Accident; want a surgeon.

Danger or Caution.

J D. You are standing into danger.
J F. You are in a dangerous position.
J P. Heavy weather coming; look sharp.

Directions to a Vessel Under Weigh.

J S. Stand off; get an offing.
J T. Tack instantly.

J W. Heave to; stop her instantly.
K B. Heave all aback; go astern.
K D. Stand on.
K F. Bear up instantly.
K G. Wear instantly.
K H. Not room to wear.
K J. Get her on the other tack, or you will be on shore.
K N. Keep to windward.
K F. Bar impassable.
K Q. Channel has altered; do not try it.
K R. Dangerous without a pilot.
K S. Buoys, or marks, are not in their proper position.
K T. Port the helm (*to be flown until course is sufficiently altered*).
K V. Starboard the helm (Ditto).
L C. Steady the helm.
L D. Steer after me.
L F. Keep on the port shore, or side of channel.
L G. Keep on starboard shore, or side of channel.
L H. Keep in centre of channel.
L M. The berth you are now in is not safe.
L N. Run on the beach. Beach the vessel.
L P. Anchor instantly.

Directions to a Vessel at Anchor.

L R. Weigh, cut, or slip; wait for nothing.
L S. Put to sea at once; get an offing.
L V. Shift your berth; your berth is unsafe.
L W. Cut away your masts.
M C. Should you part, beach where people are assembled, or by compass signal from you as will be pointed out.
M D. Do not hold on to your anchors, but let her beat up on the beach.
M F. Hold on until high water.
M H. Lose no time in shoring up.

Directions for Saving Crew.

M K. Remain by the ship.
M L. Quit the vessel as fast as possible.

M P. Landing is impossible.
M Q. Look out for a line.
M R. Endeavor to send a line.
M S. Do the best you can for yourselves; no assistance can be given.
M V. Lights or fires will be kept at the best places for coming on shore.
M W. Keep a light burning.

Distress.

N C. In distress; want assistance.
N D. I must abandon the vessel
N F. Do not abandon me.
N G. I am unmanageable.
N H. I am in danger, or shoal water; direct me how to steer.

Fire.

N M. I am on fire.
N P. Fire gains rapidly; take people off.
N Q. Want immediate assistance; fire can be extinguished.

Leak.

N S. I have sprung a leak.
N T. Leak is gaining rapidly.
N V. I am sinking.

Wants.

P C. Want assistance; mutiny.
P D. Want immediate medical assistance.
P F. Want boat, or boats, immediately.
P H. Want food; starving.
P J. Want coal immediately.
P K. Want an anchor.
P N. Want a steam-tug.
P S. Want hands.
P T. Want a pilot; can one be obtained? (*Answer* "Yes" or "No").
Q C. Repeat signal.
Q H. Stop, or heave to; I have something to communicate.

Q J. Asks for meteorological weather report.
Q K. Asks for meteorological forecast for to-morrow.
Q L. Asks hour of highest water, and minimum depth at that time. (Reply will be by: 1. A time signal. 2. A numeral signal indicating the number of feet.)
Q N. I wish to obtain orders from my owners, Mr. ——, at ——.

N. B.—*This signal to be followed by:* 1. Vessel distinguishing signal. 2. Owner's name from spelling table. 3. Owner's residence.

The International Code has been adopted by the following maritime powers, viz.:

Great Britain.	Denmark.	Russia.	Austria.	Portugal.
France.	Holland.	Greece.	Germany.	Brazil.
America.	Sweden.	Italy.	Spain.	

SIGNAL STATIONS.

Signal stations have been established at some of the most important points on the coasts of the United Kingdom, as follows:

Aldborough.	Dover.	Penzance.
Bridlington.	Dungeness.	The Scilly Islands.
Flamboro' Head.	Yarmouth, I. of W.	Roche's Point.
Grimsby.	St. Catherine's Point, (I. of W.)	Queenstown.
Yarmouth, Norfolk.		Holyhead.
Broadstairs.	Prawle Point, near the Start.	Caldy Island (Tenby).
Deal.		Cardiff.

Signal Stations have also been established at,

Straits of Sunda.	Ascension.	Oxo, Christiansand.
Straits of Messina.	Cape Point, C. G. H.	Elsinore.
Gibraltar.	Heligoland.	Palais, Belle Isle.
St. Helena.	Skagen, N. of Jutland.	Sulina, Danube.

At these signal stations the International Code is the only code recognized, and vessels of any nation which make their names known by means of the International Code in passing these stations will be reported in the *Shipping Gazette*.

SIGNALS FOR PILOTS.

"**In the Daytime.**—The following signals, numbered 1 and 2, when used or displayed together or separately, shall be deemed to be signals for a pilot in the daytime, viz.:—

"1. To be hoisted at the fore, the Jack or other National color usually worn by merchant ships, having round it a white border one-fifth of the breadth of the flag; or

"2. The International Code Pilotage Signal, indicated by P. S.

"**At Night.**—The following signals, numbered 1 and 2, when used or displayed together or separately, shall be deemed to be signals for a pilot at night, viz.:—

"1. The pyrotechnic light, commonly known as a blue light, every fifteen minutes; or

"2. A bright white light, flashed or shown at short or frequent intervals, just above the bulwarks, for about a minute at a time.

SIGNALS OF DISTRESS.

"**In the Daytime.**—The following signals, numbered 1, 2, and 3, when used or displayed together or separately, shall be deemed to be signals of distress in the daytime:—

"1. A gun fired at intervals of about a minute.

"2. The International Code Signal of distress indicated by N. C.

"3. The distant signal, consisting of a square flag, having either above or below it a ball, or anything resembling a ball.

"**At Night.**—The following signals, numbered 1, 2, and 3, when used or displayed together or separately, shall be deemed to be signals of distress at night:—

"1. A gun fired at intervals of about a minute.

"2. *Flames* on the ship (as from a burning tar barrel, oil barrel, *etc.*).

"3. Rockets or shells of any color or description fired one at a time at short intervals."

And "any Master of a vessel who uses or displays, or causes or permits any person under his authority to use or display any of the said signals, except in the case of a vessel being in distress, shall be liable to pay compensation for any labor undertaken, risk incurred, or loss sustained, in consequence of such signal having been supposed to be a signal of distress; and such compensation may, without prejudice to any other remedy, be recovered in the same manner in which salvage is recoverable."

WEATHER INTELLIGENCE.

Signal Stations on the Coast of the United States.

There are no coasts so fully guarded by the display of storm signals as the coast of the United States. The act of Congress requiring this service contemplates the establishment of signal stations at life-saving stations, and lighthouses at points along the coast in such manner that the coast and sea in their vicinity may be at once kept under observation, warning of approaching storms be given to vessels within signal distance, and information of disasters occurring be rapidly conveyed to the life-saving stations, to lighthouses, ports from which aid may come in case of need, and to the main office.

Vessels passing in view can be at once warned by signals of coming danger, or be aided if in distress.

It has been a source of complaint among the seafaring men on all those coasts on which storm-signals have been attempted to be displayed, that while it might be learned by vessels lying in port, with reasonable certainty, whether or not a storm was so impending as to render it unsafe to risk exposure at sea, there was no plan of storm signals devised by which it could be communicated to vessels actually at sea, and in sight of the stations, beyond the mere fact that a storm was threatening, and from what direction it was to be expected. It was not possible to advise on what coasts it would be dangerous; whether or not any particular voyage might be continued with safety, or when and where shelter ought to be sought.

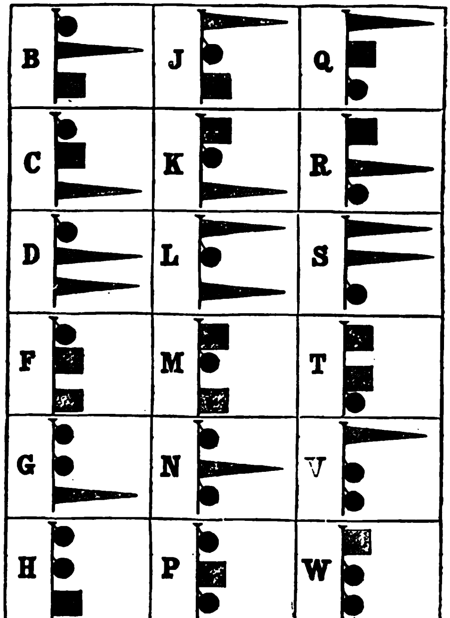
The connection by means of telegraphic lines with all sea-coast stations and the main office has lessened these difficulties.

GENERAL ALPHABETICAL TABLE for Composing Distance Sign

Preparative  Answering

and also
Stop after each complete Signal.

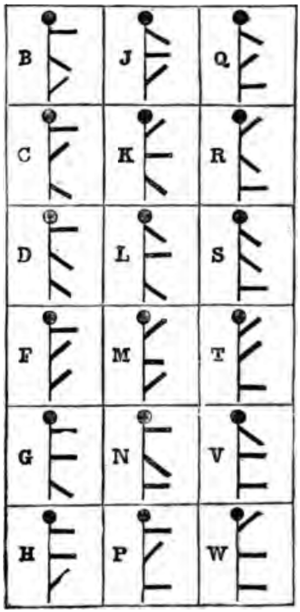
Annul Signal.



Semaphore Signals.

Semaphore masts are furnished with *Three Arms*, which are used as follows in the representation of any of the Distance Signals :—

1. The *Disk* at the *top of the mast* indicates that signals are being made by the *International Code*, and it must remain there whilst so signalling. It is a large *black disk with white rim*.



2. Any *arm* pointing *downward* represents a PENNANT.

3. Any *arm* in a *horizontal* position represents a BALL.

4. Any *arm* pointing *upward* represents a FLAG.

When the arms are not working they are not visible, but lie parallel with the masts.

The Lakes.

Alpena, Mich.	Green Bay, Wis.	Pentwater, Mich.
Ashtabula, Ohio.	Horn's Pier, Wis.	Port Austin, Mich.
Bay City, Mich.	Kenosha, Wis.	Port Huron, Mich.
Buffalo, N. Y.	Kewaunee, Wis.	Racine, Wis.
Cape Vincent, N. Y.	Ludlington, Mich.	Rochester, N. Y.
Charlotte, N. Y.	Mackinac City, Mich.	Rogers City, Mich.
Chicago, Ill.	Manitowoc, Wis.	St. Joseph, Mich.
Cleveland, Ohio.	Marquette, Mich.	Sandusky, Ohio.
East Tawas, Mich.	Menomonee, Mich.	Sheboygan, Wis.
Erie, Pa.	Milwaukee, Wis.	South Haven, Mich.
Escanaba, Mich.	Monroe, Mich.	Sturgeon Bay, Wis.
Fairport, Ohio.	Muskegon, Mich.	Toledo, Ohio.
Forester, Mich.	Northport, Mich.	Traverse City, Mich.
Grand Haven, Mich.	Oswego, N. Y.	

The occurrence of a storm area registering a wind velocity of twenty-five miles per hour on land, indicating a much greater velocity at ten or twenty miles from the land, is taken as the lowest velocity justifying a signal.

COAST OF GREAT BRITAIN.

Telegraphic Weather Intelligence.

The Meteorological Office issues (free of charge) to ports and fishing stations approved of by the Board of Trade, notices of atmospherical disturbances on or near the coasts of the British Islands.

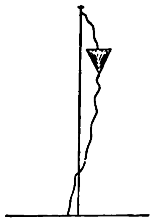
Signals.—The fact that such a notice has been received at any station is made known by a signal, which is hoisted on the receipt of the message, and remains hoisted, but only during the daytime, for the space of forty-eight hours, and no longer—counted from the time the message is sent out.

The signals are made by means of two canvas shapes, a Cone and a Drum.

The Cone is three feet high and three feet wide at base, and appears as a triangle when hoisted.

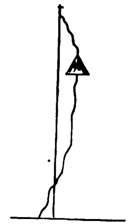
The Drum (or cylinder) is three feet high and three feet wide, and appears as a square when hoisted.

Southerly Gale.—The Cone, *point downward*, means that strong winds are probable, at first from the southward (from S. E., round by S. to N. W.).

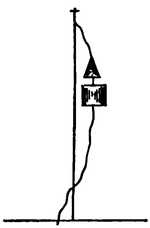


Gale probably from the southward.

Northerly Gale.—The Cone, point upward, means that strong winds are probable, at first from the northward (from N. W., round by N. to S. E.).

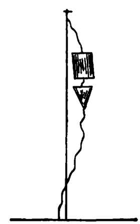


Gale probably from the northward.



Dangerous wind, probably at first from the northward.

Very Heavy Gales.—The Drum will be hoisted with the Cone whenever a very heavy gale, either southerly or northerly, as the case may be, is probable. The Drum will not be used without the Cone.

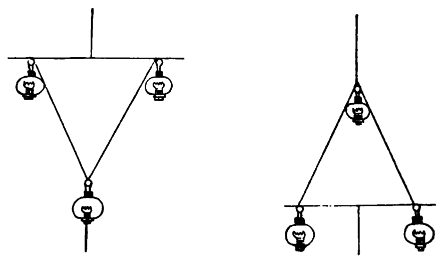


Dangerous wind, probably at first from the southward.

Sudden Shifts of Wind.—No signal is employed to indicate a wind which is likely to shift suddenly, but it must be remembered, that a southerly wind is much more likely to veer to a point north of west than a northerly wind is to veer to a point south of east; accordingly, when the south signal cone is hoisted, and the anchorage or harbor is exposed to the northwest, it is advisable to make preparations for a northwest gale.

On Hoisting the Signals.—The signal is to be kept flying until dusk, then lowered, and hoisted again next morning; and so on until the end of forty-eight hours from the time the message has been issued from London (which is always marked on the telegram), unless orders are received previously to lower the signal.

Night Signals.—At dusk, whenever a signal ought to be flying if it were daylight, a night signal may be hoisted in place of the Cone, consisting of three lanterns hung on a triangular frame, point downward, or point upward, as the case may be. It is not considered necessary to hoist lanterns to represent the Drum. They should be kept burning until late in the evening, say 9 or 10 o'clock.



Three lanterns and one yard 4 feet long will be sufficient.

These signals may be made with any lanterns, showing a white or any color, but *alike*. Red is best. Lamps are better than candles. The halyards should be good rope, and protected from chafing. The lanterns should hang, at least, three feet apart.

No warning messages can be issued on Sundays, as the telegraph offices are almost all closed after 10 A.M. on that day, so that the signal must sometimes be kept flying on Sundays longer than is necessary. Storms, first showing signs of their approach on Sunday, will sometimes come on before Monday, so that the warning cannot be issued in time to be of service.

Meaning of Signal.—The hoisting of any of these signals is intended as a sign that there is an atmospherical disturbance in exist-

ence in the neighborhood, which will *probably* cause a gale from the quarter indicated by the signal (say, within a distance of fifty miles of the place where the signal is hoisted), the knowledge of which is likely to be of use to the sailors and fishermen on that part of the coast. Its meaning is, simply, "Look out! It is probable that bad weather of such and such a character is approaching you."

Hitherto it has been found that, at least, *three* out of *five* signals of approaching storms (force, upward of eight, Beaufort scale, a "Fresh Gale"), and *four* out of *five* signals of approaching strong winds (force, upward of six, Beaufort scale, a "Strong Breeze"), have been fully justified.

In every case some of the principal reasons which have led to the hoisting of the signal are explained in the telegram, which should always be kept posted up for public inspection while the signal is flying.

It must be remembered that only the greater and more general disturbances of the atmosphere can be made known by this method. Local changes of less extent may be indicated to observers by their own instruments and by local signs of weather, etc.

The signal will sometimes be kept flying after the gale is over; this is the case because often one gale is followed by another before the forty-eight hours are out. In every case, when it is thought at the Meteorological Office that immediate danger is over, orders are issued to lower the signal.

Section 2.

THE MARINER'S COMPASS, ITS ERRORS AND THEIR CORRECTION.

THE LOG LINE AND TIME GLASSES, PATENT LOGS, ETC.

LEADS, LEAD LINES, AND SOUNDING MACHINES.

THE QUADRANT AND SEXTANT, ADJUSTMENTS, ETC.

LIGHTS AND BEACONS.
LIGHT HOUSE ESTABLISHMENT.
LIGHT HOUSE DISTRICTS.
BUOYAGE OF CHANNELS.

DEPTH OF WATER IN CHANNELS, RIVERS AND HARBORS OF THE UNITED STATES.

A Table of the Angles

WHICH EVERY POINT AND QUARTER POINT OF THE COMPASS MAKES WITH THE MERIDIAN.

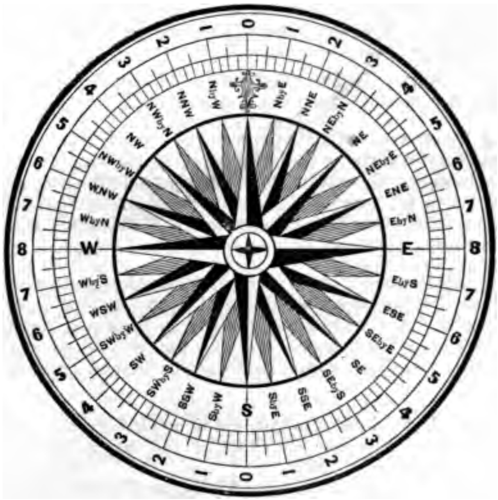
Opposite or Back Bearings.		Points.	Degrees, &c			Points.	Opposite or Back Bearings.	
			°	′	″			
North.	South.	0	0	0	0	0	North.	South.
		0 ¼	2	48	45	0 ¼		
N. ½ E.	S. ½ W.	0 ½	5	37	30	0 ½	N. ½ W.	S. ½ E.
		0 ¾	8	26	15	0 ¾		
N.b.E.	S.b.W.	1	11	15	0	1	N.b.W.	S.b.E.
		1 ¼	14	3	45	1 ¼		
N.b.E. ½ E.	S.b.W. ½ W.	1 ½	16	52	30	1 ½	N.b.W. ½ W.	S.b.E. ½ E.
		1 ¾	19	41	15	1 ¾		
N.N.E.	S.S.W.	2	22	30	0	2	N.N.W.	S.S.E.
		2 ¼	25	18	45	2 ¼		
N.N.E. ½ E.	S.S.W. ½ W.	2 ½	28	7	30	2 ½	N.N.W. ½ W.	S.S.E. ½ E.
		2 ¾	30	56	15	2 ¾		
N.E.b.N.	S.W.b.S.	3	33	45	0	3	N.W.b.N.	S.E.b.S.
		3 ¼	36	33	45	3 ¼		
N.E. ½ N.	S.W. ½ S.	3 ½	39	22	30	3 ½	N.W. ½ N.	S.E. ½ S.
		3 ¾	42	11	15	3 ¾		
N.E.	S.W.	4	45	0	0	4	N.W.	S.E.
		4 ¼	47	48	45	4 ¼		
N.E. ½ E.	S.W. ½ W.	4 ½	50	37	30	4 ½	N.W. ½ W.	S.E. ½ E.
		4 ¾	53	26	15	4 ¾		
N.E.b.E.	S.W.b.W.	5	56	15	0	5	N.W.b.W.	S.E.b.E.
		5 ¼	59	3	45	5 ¼		
N.E.b.E. ½ E.	S.W.b.W. ½ W.	5 ½	61	52	30	5 ½	N.W.b.W. ½ W.	S.E.b.E. ½ E.
		5 ¾	64	41	15	5 ¾		
E.N.E.	W.S.W.	6	67	30	0	6	W.N.W.	E.S.E.
		6 ¼	70	18	45	6 ¼		
E.b.N. ½ N.	W.b.S. ½ S.	6 ½	73	7	30	6 ½	W.b.N. ½ N.	E.b.S. ½ S.
		6 ¾	75	56	15	6 ¾		
E.b.N.	W.b.S.	7	78	45	0	7	W.b.N.	E.b.S.
		7 ¼	81	33	45	8 ¼		
E. ½ N.	W. ½ S.	7 ½	84	22	30	8 ½	W. ½ N.	E. ½ S.
		7 ¾	87	11	15	8 ¾		
East.	West.	8	90	0	0	8	West.	East.

Mariners' Compass of Various Nations.

English.	French.	Italian.	Spanish.	German.	Dutch.	Swedish, Norwegian, Danish.
NORTH.	Nord.	Tramontana	Norte.	Nord.	Noord.	Nord.
N. b E.	N. q. N. E.	T. quarto G.	N.cuartoN.E.	N. zu O.	N. ten O.	N. til O.
N.N.E.	N.N.E.	G.T.	N.N.E.	N.N.O.	N.N.O.	N.N.O.
N.E. b N.	N.E.quart N.	G. quarto T.	N.E.cuartoN.	N.O. zu N.	N.O. ten N.	N.O.tilN.
N.E.	N.E.	Greco.	N.E.	N.O.	N.O.	N.O.
N.E. b E.	N.E.quart E.	G. quarto L.	N.E.cuarto E.	N.O. zu O.	N.O. ten O.	N.O.til O.
E.N.E.	E.N.E.	G.L.	E.N.E.	O.N.O.	O.N.O.	O.N.O.
E. b N.	E.quart N.E.	L. quarto G.	E.cuarto N.E.	O. zu N.	O. ten N.	O. til N.
EAST.	Est.	Levante.	Este.	Ost.	Oost.	Ost.
E. b S.	E. quart S.E.	L. quarto S.	E. cuarto S.E.	O. zu S.	O. ten Z.	O. til S.
E.S.E.	E.S.E.	S.L.	E.S.E.	O.S.O.	O.Z.O.	O.S.O.
S.E. b E.	S.E. quart E.	S. quarto L.	S.E. cuarto E.	S.O. zu O.	Z.O. ten O.	S.O. tilO.
S.E.	S.E.	Scirocco.	S.E.	S.O.	Z.O.	S.O.
S.E. b S.	S.E. quart S.	S. quarto O.	S.E. cuarto S.	S.O. zu S.	Z.O. ten Z.	S.O. til S.
S.S.E.	S.S.E.	O.S.	S.S.E.	S.S.O.	Z.Z.O.	S.S.O.
S. b E.	S. quart S.E.	O. quarto S.	S. cuarto S.E.	S. zu O.	Z. ten O.	S. til O.
SOUTH.	Sud.	Ostro.	Sur.	Sud.	Zuid.	Syd.
S b W.	S. quart S.O.	O. quarto L.	S. cuarto S.O.	S. zu W.	Z. ten W.	S. til V.
S.S.W.	S.S.O.	O.L.	S.S.O.	S.S.W.	Z.Z.W.	S.S.V.
S.W. b S.	S.O. quart S.	L. quarto O.	S O. cuarto S.	S.W. zu S.	Z.W. ten Z.	S.V.til S.
S.W.	S.O.	Libeccio.	S.O.	S.W.	Z.W.	S.V.
S.W. b W.	S.O. quart O.	L. quarto P.	S.O.cuarto O.	S.W. zu W.	Z.W.ten W.	S.V.til V.
W.S.W.	O.S.O.	P.L.	O.S.O.	W.S.W.	W.Z.W.	V.S.V.
W. b S.	O. quart S.O.	P. quarto L.	O.cuarto S.O.	W. zu S.	W. ten Z.	V. til S.
WEST.	Ouest.	Ponente.	Oeste.	West.	West.	Vest.
W. b N.	O.quart N.O.	P. quarto M.	O.cuarto N.O.	W. zu N.	W. ten N.	V. til N.
W.N.W.	O.N.O.	P.M.	O.N.O.	W.N.W.	W.N.W.	V.N.V.
N.W. b W.	N.O.quart O.	M. quarto P.	N.O.cuarto O.	N.W.zu W.	N.W.ten W.	N.V.tilV.
N.W.	N.O.	Maestro.	N.O.	N.W.	N.W.	N.V.
N.W. b N.	N.O.quart N.	M. quarto T.	N.O.cuarto N.	N.W.zu W.	N.W. ten N.	N.V.tilN.
N.N.W.	N.N.O.	M.T.	N.N.O.	N.N.W.	N.N.W.	N.N.V.
N. b W.	N.quart N.O.	T. quarto M.	N.cuarto N.O.	N. zu W.	N. ten W.	N. til V.

In the French Compass the abbreviation is q as N. q N.E. or N. ¼ N.E.
" Italian " " q as T. q G. or T. ¼ G.
" Spanish " " c as N. c N.E. or N. ¼ N.E.
" German " " z as N. z O.
" Dutch " " t as N. t O.
" Swedish / " Norwegian / " Danish " " t as N. t O.
(German, Dutch, Swedish, Norwegian, Danish) equivalent to the English by.

THE MARINER'S COMPASS.



THE mariner's compass consists of three principal parts—the card, the needle attached to it, and the bowl or case.

The whole is enclosed in a compass box or binnacle. The surface of the card is divided into thirty-two parts, each containing 11° 15′—these constitute the *points* of the compass; the half points and quarters are subdivisions of the same.

The north pole is denoted on the card by a fleur-de-lis; and the line which joins the north and south poles passes through the axis of the needle.

The card is directed by the needle, which, with it, is pivoted on a vertical axis, and is usually suspended on a central jewelled cap, the point of suspension being of a similar hard material. On the inside

of the compass bowl is a vertical line known as *lubber's point*, and this and the pivot of the card are in the same plane as the vessel's keel. The compass is kept horizontal by the use of *gimbals*, which consist of a ring moving freely on an axis, within which it swings on an axis at right angles.

Boxing the Compass is the enumeration by name of the thirty-two points which are marked upon the compass card.

Steering Compass.—When the compass card, with needles attached, rests on the pivot in the bowl with the lubber's point directed toward the ship's head, and in the midship line, the instrument for steering purposes is complete. The point of the compass close by the lubber's point is said to be the *direction of the ship's head by compass*, or her *course* by compass.

Azimuth Compass.—This is an instrument similar to the steering compass, but of superior make; the card is also divided into degrees, and the case is fitted with a movable ring, to which are attached (exactly opposite to each other, and in a line with the centre of the compass card,) two sight vanes that can be turned down when not in use.

Variation and Deviation.—The chief conditions that affect the use of the mariner's compass are those of the magnetic declination, or *variation*, and the *deviation*.

The variation is the angle contained between the true and the magnetic meridian; this angle varies according to locality, and there are annual and diurnal variations of small amount.

The deviation of the compass is the departure of the north and south line from the *magnetic* meridian, owing to the magnetism of the ship itself, or that induced in it by the earth's magnetic force.

Two methods are employed to eliminate this error in practice: the first is by ascertaining the actual deviation in every position of the ship with regard to the magnetic meridian, and working by a table of errors; the other is by introducing on board ship masses of iron and magnets, to neutralize exactly the action of the ship's magnetism.

Both methods, the compensation and the tabular, have their advocates. In the United States Navy uncompensated compasses are in

general use. The majority of merchant vessels use compensated compasses.

In some iron vessels, where the deviation on particular courses is very large, a combination of the two methods is used, the errors being partially compensated by magnets and the residual error being found by observation and tabulated.

The Standard Compass.

This instrument is so constructed as to answer the purpose of a steering compass and an azimuth compass. It should be placed as far as possible from any considerable mass of iron, and should not be within ten feet of the extremity of any elongated piece of iron, *especially if vertical*, such as the spindle of the capstan, iron masts, stanchions, davits, funnels, transverse iron bulkheads, etc., and not less than five feet above the deck. When of necessity the compass is placed well aft, in an *iron* ship, it should not be within half the width of the ship from the stern-post.

No stand of arms, or iron subject to occasional removal, should be placed within at least fourteen feet of the standard compass, whether on the same deck, or below it.

When the ship is ready for the sea, *and with davits and other iron work secured in the positions in which it is intended they shall remain at sea*, then the deviation of the compass from the magnetic meridian should be ascertained by one of the following methods:—

Process by Bearing of a Distant Object.

The ship is to be gradually swung round, so as to bring her head successively upon each of the thirty-two points of the compass; and as her head approaches each of these points, so gently to check her motion as to prevent any continued swing of the card. When the ship is quite steady, and her head exactly on any one point, the direct bearing of some distant but well defined object is to be observed with the standard compass and registered.

The ship's head is then to be warped round in the same manner to the next point, and when duly stopped and steadied there, the bearing of the same object is again taken, and again recorded; and so on, point after point, till the exact bearing of the object has been as-

certained with the ship's head on every separate point of the compass.

The object selected for that purpose should be at such a distance from the ship, that the diameter of the space through which she revolves shall make no sensible difference in its real bearing. If she be at anchor in a tideway, a steeple or a large tree, at not less than from seven to eight miles distance, will well answer the purpose.

The next step is to determine the *real* or correct magnetic bearing of the selected object from the ship; or, in other words, the compass bearing which it would have from on board, if the compass were not disturbed by the attraction of the iron in the ship.

This may be effected by taking the mean of all the observed bearings, if observed on equidistant points; but perhaps the better way is to carry the compass to some place on the adjacent wharf or shore, from whence the part of the ship where the compass stood, and the distant object, shall both be exactly in one line with the observer's eye. The bearing of the object from that point will evidently be the same as its correct magnetic bearing from the ship by that compass. The difference between this correct magnetic bearing of the object, and the bearing observed with the standard compass on board, when the ship's head is on any particular point, will show the error caused by the ship's iron on that point, or, in other words, the *deviation* of the standard compass, according to the direction in which the ship's head was placed.

Process by Reciprocal Bearings.

Should there be no suitable object visible from the ship, and at the requisite distance, the deviations must be ascertained by the process of Reciprocal Bearings. A careful observer must go on shore with a second compass, and place its tripod in some open spot, where it may be distinctly seen from the standard compass on board. Then by means of signals, the mutual bearings of those two compasses from each other are to be observed at the moment when the ship's head is steady on each of the thirty-two points successively, as before directed.

To insure the success of this operation, the compass on shore should not be more distant from the ship than is consistent with the most distinct visibility with the naked eye of both compasses from

each other. The observations should be made simultaneously. And to guard against any mistake, such as might be occasioned by a signal being misinterpreted, the time at which each bearing is taken should be noted, both on shore and on board, by compared watches.

Before this practice is complete, the standard compass should be carried on shore, in order to be compared with the compass which has been employed there, by means of the bearing of some distant object; and the difference, if any, is to be recorded. This comparison of the two compasses may well be made previously to the observations; and in all cases when compasses are compared, the caps, pivots, etc., should be first carefully examined.

During either of the processes for ascertaining the deviations of the standard compass, when the ship's head pauses at each point, it is desirable to note, in a separate table, the corresponding directions of her head by the binnacle compasses.

In steam vessels fitted with telescopic funnels, and when the standard compass is placed near to the steam machinery, the deviation is materially altered by the elongated or compressed state of the funnel. In swinging vessels therefore, so fitted, and when the funnel is within thirty or forty feet of the compass, it is necessary that, on the eight principal points of the compass at least, the deviations should be ascertained in both conditions of the funnel.

Process by Azimuths and Amplitudes of the Sun or other Heavenly Bodies.

By this process, during the course of a voyage, especially near sunset or sunrise, and with a tranquil sea, a deviation table can be formed by steaming or sailing round a circle in the course of half an hour. The ship should be kept upright in order to avoid heeling error.

The comparison of the true azimuth with the bearing by compass gives the combined error of variation and deviation, which is the *correction* to be applied to courses steered on the same line of equal variation, with the ship's head in the same direction as when the azimuth was taken, and the variation enables the mariner to separate the two.

The best method of determining the difference between the true and compass bearings is by time azimuths; it requires but one ob-

server, and is always available whether the ship is in port or at sea, when the altitude cannot be observed on account of the horizon not being visible. With the aid of Burdwood's or Davis' tables the sun's true bearing can be obtained by inspection, if the apparent time at the ship, the latitude, and declination be known. The difference between the sun's *true* bearing and the sun's *compass* bearing, as observed with the ship's head on any particular point of the compass, is the amount of the deviation on that point, combined with the variation of the compass due to the geographical position. By deducting the latter from the difference of bearings observed, the deviation is obtained.

It must be remembered that the corrections found for the standard compass belong to that compass alone, and to that compass only while it is in its proper place; and that those corrections will furnish no guide whatever to the effects of the ship's iron on a compass placed in any other part of the ship. It is essential, therefore, that the ship's course should not only be invariably directed by the standard compass, but that all the courses and bearings inserted in the log should be those shown by that compass alone; the binnacle compass being regarded solely as a guide to the helmsman.

When the ship has been placed on her proper course by the standard compass, the helmsman will notice the point shown by the binnacle compass as being that to which he has to attend; and a comparison of the two compasses should be frequently repeated by the officer of the watch or the quartermaster, and should always be made when any alteration occurs in the course, or when the ship heels over. When the ship is by the wind, the apparent course by the *standard compass* is that which must be inserted in the log.

Wooden and Composite-built Ships.

In wooden sailing ships the points of maximum deviation of the compass are at east and west; their deviation, which is small, arises from induced magnetism in vertical iron, the effects of which vary as the tangent of the dip of the needle. In the northern hemisphere the deviation is easterly on easterly courses, and westerly on westerly courses. In the southern hemisphere the reverse is the case.

In wooden steamships, where the machinery and boilers are before

the compass, the deviation in the northern hemisphere is of the same character as that of wooden sailing vessels in that hemisphere; but the changes that occur in the deviation of the former are not the same as in that of the latter. In the southern hemisphere the deviation of wooden steamships is of the same character as in the northern hemisphere, but much reduced in amount. This is owing to the permanent attraction exerted by the machinery. Composite ships follow the same laws in the deviations of their compasses as do iron ships.

Heeling Error.

Experience has shown that the deviations in iron and composite vessels are affected by the heeling of the ship, the magnitude of the error so resulting being proportional to the amount of heel. The maximum disturbance when heeling occurs when the ship's head is *north* or *south*, by the compass, the disturbance vanishing when the ship's head is *east* or *west*.

It is therefore necessary to ascertain by repeated observations at sea the degrees of error arising from the various conditions of heeling both to starboard and to port.

The heeling error is caused: 1, by the vertical force of the ship's magnetism which was acquired while building; 2, by vertical induction in vertical soft iron; and, 3, by vertical induction in the beams which are also soft iron. As a general rule in ships built in England, the north end of the needle, when the ship heels, is drawn to windward or to the high side of the ship, and the heeling error is therefore said to be to windward; but in some ships, notably those built with their heads to the southward, the heeling error is to leeward. Ships having a heeling error to windward will, on northerly courses, be to windward of their reckoning, and on southerly courses, to leeward. With those having a leeward heeling error, the reverse is the case. On proceeding to south latitudes, those vessels which have a windward heeling error in north latitudes will have the error much diminished and possibly reversed; whereas those which have a leeward heeling error in north latitudes will have it much increased in south latitudes.

Many valuable ships have been lost through unknown or unallowed for heeling errors.

The Mechanical Correction of the Deviation of the Compass.

The Deviation of the Compass is composed of three parts, viz.: the *Semicircular* Deviation, the *Quadrantal* Deviation, and the *Heeling* error.

The Semicircular Deviation is due chiefly to the permanent magnetism acquired by the ship while building: the ship is a magnet, the direction of the magnetism of which may be inferred from the direction in which the ship's head was while building. The direction of the ship's magnetic force coincides nearly with the line drawn on deck in a magnetic north and south direction, and the points of maximum semicircular deviation are at right angles to the direction of the ship's head in building; thus, in a ship built with her head north, the points of maximum semicircular deviation are at east and west, and there will be no such deviation at north and south.

In the majority of cases, the ship's magnetic force acts in a direction diagonal to the fore and aft line of the ship, and therefore it is convenient to consider the ship's force, causing the semicircular deviation, as made up of two components, one acting in a fore-and-aft direction and producing a deviation named B, the other acting in an athwartship direction and producing a deviation named C, which combined constitute the semicircular deviation.

To destroy the effect of a magnetic disturbing force we must introduce another disturbing agent, whose force follows the same laws and has the same magnitude, but which acts in the opposite direction. If, therefore, in the semicircular deviation B and C are known, the direction in which the counteracting forces should be introduced can be determined, and the deviation be corrected.

By a Single Magnet.

This method is very convenient for standard compasses, which, occupying favorable positions, are subject only to small changes of deviation.

The following process is required: Place the ship's head *East* by compass and observe the deviation; this deviation is approximately the value of B, marked + if the deviation is easterly, and — if westerly; then place the ship's head *North*, and the deviation on that

point is the approximate value of C, marked + if the deviation be easterly, and − if westerly. Enter the traverse table with B as diff. lat. and C as departure, and take out the course and distance. The course indicates the inclination to the fore-and-aft line at which the correcting magnet must be placed, and the distance the amount of semicircular deviation to be corrected. The position the correcting magnet should occupy may be found by taking a compass on shore and placing the magnet in an east and west direction, with its centre due north and south from the compass, and moving the magnet to or from the compass until it produces a deflection equal to the semicircular deviation which is to be corrected. At the distance thus determined, the magnet should be placed with its centre directly below the centre of the compass-card, parallel to the plane of the deck, and with its edge upward.

The magnet, however, should not be nearer to the centre of the card than twice the length of the needle. If necessary a stronger magnet should be used.

If the semi-circular deviation consist of

+ B and + C, the north end of the magnet should point on the Starboard bow.

+ B and − C, the north end of the magnet should point on the Port bow.

− B and + C, the north end of the magnet should point on the Starboard quarter.

− B and − C, the north end of the magnet should point on the Port quarter.

EXAMPLE.—The deviation of the compass on board the Royal Oak, head East, is 10° westerly; head North, 9° easterly. Entering the traverse table with − B 10 as diff. lat. and + C 9 as departure, the course found is 42°, and the distance 13½.

The north end of the magnet should therefore point on the starboard quarter, at an angle of 42° with the fore-and-aft line. With a ten-inch magnet the distance will be about one foot ten inches below the card.

For the general purposes of compass correction, the values of B and C as determined from the deviations on two adjacent cardinal points is sufficiently correct; but if desired the value of B can be more accurately determined by taking the mean of the deviations at east and west, the latter deviation with the sign changed; and of C,

by taking the mean of the deviations at north and south, the latter with the sign changed.

Care should be taken that the ship be on an even keel while the compasses are being corrected.

By Two Magnets.

This operation requires no calculation, and is the one generally adopted in the mercantile marine. Place the ship's head East or West, correct magnetic; then place a magnet in a fore-and-aft direction, with the middle of its length in the vertical plane passing athwartship through the centre of the compass-card; alter the distance of the magnet until the compass points correctly: that part of the semicircular deviation called B is thus corrected. Similarly, with the ship's head North or South, correct magnetic, place a magnet athwartships parallel to the deck, with the middle of its length in the vertical plane passing fore and aft through the centre of the compass; move the magnet nearer or further off until the compass points correctly, that part of the semicircular deviation called C is thus corrected.

The B, or fore-and-aft magnet, may be placed either on the starboard or port side of the compass, and the C magnet either on the fore or after side of the compass; but neither magnet should be in the same horizontal plane as the card, nor within twice the length of the compass-needle from the centre of the compass-card. The magnets may be secured to the sides of the binnacle or to the deck, if necessary, but precautions are requisite that they be not reversed at any time.

It is well to bear in mind that a rapid change takes place in the magnetism of ships newly launched, and the magnets in such cases will require readjusting. Also in compasses unfavorably placed the magnets will require readjusting on a considerable change of geographical position.

The semicircular deviation of the compass in an iron ship alters when the vessel has lain a long time on the same course, or has been a long time alongside a wharf, or in a dock, with her head in one direction.

THE QUADRANTAL DEVIATION of the compass is due solely to *the soft iron of the ship.* The earth's magnetic force *induces* in the

soft iron a magnetic force, which produces the greatest effect when the ship is on the quadrantal points, viz.: N.E., S.E., S.W., and N.W., and no effect when she is on the cardinal points. Such deviation is caused chiefly by the iron beams of the ship, and generally it is easterly when the ship's head points in the N.E. and S.W. quadrants, and westerly when it points in the N.W. and S.E. quadrants; its amount does not, except in some iron-clad ships, usually exceed 6°. Quadrantal deviation does not change either with lapse of time or change of geographical position. To find the amount of the quadrantal deviation, take half the algebraic sum of the deviations on the N.E. and S.W. points; thus, in the English iron-clad ship Achilles the deviation at N.E. is 24° 10′ East, or +, the deviation at S.W. is 10° 30′ W. or −; half the algebraic sum of these two is + 6° 50′. To find the quadrantal deviation from the deviations on the N.W. and S.E. points, the signs of both quantities must be changed; thus, in the Achilles the deviation at N.W. is 19° 30′ W. (or −), at S.E. 6° E. (or +); half the algebraic sum of + 19° 30′ and − 6° is + 6° 45′. A mean of + 6° 50′ and + 6° 45′ is 6° 48′, which is a more accurate value of the quadrantal deviation.

As this deviation is caused by soft iron, we must use soft iron to correct it, and this is not easy in practice, owing to the difficulty of getting iron magnetically "soft," or free from permanent magnetism, and also from the close proximity to the compass which the correctors must occupy. On this account, as well as from the fact that the quadrantal deviation is unvarying and generally of moderate amount, its mechanical correction is not always made. For the correction of large quadrantal deviations cast-iron cylinders from nine to twelve inches long are placed on a level with the compass-needle; for smaller amounts, boxes containing small iron chain or pieces of annealed wire are used, one on each side of the compass.

THE HEELING ERROR is mechanically corrected by a magnet placed in a vertical position under the centre of the compass-card at such a distance as shall be found suitable. This distance may be found by heeling the ship about 10°, with her head in the direction which was north by compass when she was upright; then place the magnet accurately in position perpendicular to the deck. With windward heeling error the north end of the magnet should be uppermost, with leeward error the south end. Raise or lower the magnet until the compass points correctly.

This correction is perfect only while the ship remains in the same magnetic latitudes; and a ship corrected for heeling error in north latitude must have the magnet readjusted when she changes to south latitude.

As the mechanical correction does not remove the whole of the deviation of the compass, *the ship should be swung after the magnets have been fixed in their places, to ascertain the remaining deviation.*

To Correct the Compass for Deviation.

RULE.—*To correct a compass course steered, take the deviation on that point*—then—

Deviation *westerly*, allow it to the *left* to get correct magnetic course.

Deviation *easterly*, allow it to the *right* to get correct magnetic course.

Express the course in degrees, when applying the deviation.

Example.—Compass course being S.E., *i.e.*, S. 45° E., with deviation 22° W., gives the correct magnetic course S. 67° E.

Example.—Compass course being west, with deviation 18° E., gives correct magnetic N. 72° W.

Example.—Compass course being E.N.E., with deviation 11° W., gives correct magnetic N. 56½° E.

Example.—Compass course being N. by W. ½ W., with deviation 8½° E. (half sum of 7½ and 9½), gives correct magnetic N. 8½° W.

COMPASS BEARINGS (with deviation) require to be corrected, *not for the deviation on the bearing*, but for the deviation on the direction of the ship's head (or course): thus:—Object's bearing (by compass) S.W., with ship's head N.W., the deviation on N.W. (by card below) being 12° E., the *correct* magnetic bearing will be S. 57° W.

Deviation Card of the Standard Compass—Ship "Navigation."

1 Ship's Head (course) by Standard Compass.	2 Deviation.	3 Correct Magnetic Course made good.	1 Ship's Head (course) by Standard Compass.	2 Deviation.	3 Correct Magnetic Course made good.
N.	6° E.	N. 6° E.	S.	6° W.	S. 6° E.
N. by E.	4¼ E.	N. 15½ E.	S. by W.	0½ W.	S. 10¾ W.
N.N.E.	2 E.	N. 24½ E.	S.S.W.	4½ E.	S. 27 W.
N.E. by N.	0½ W.	N. 33¼ E.	S.W. by S.	9½ E.	S. 43¼ W.
N.E.	3½ W.	N. 41½ E.	S.W.	13½ E.	S. 58½ W.
N.E. by E.	7 W.	N. 49¼ E.	S.W. by W.	16¼ E.	S. 72½ W.
E.N.E.	11 W.	N. 56½ E.	W.S.W.	17½ E.	S. 85 W.
E. by N.	14½ W.	N. 64¼ E.	W. by S.	18½ E.	N. 82¾ W.
E.	18 W.	N. 72 E.	W.	18 E.	N. 72 W.
E. by S.	20¾ W.	N. 80½ E.	W. by N.	17 E.	N. 61¾ W.
E.S.E.	22¼ W.	S. 89¾ E.	W.N.W.	15½ E.	N. 52 W.
S.E. by E.	23 W.	S. 79¼ E.	N.W. by W.	13¾ E.	N. 42½ W.
S.E.	22 W.	S. 67 F.	N.W.	12 E.	N. 33 W.
S.E. by S.	19½ W.	S. 53¼ E.	N.W. by N.	10½ E.	N. 23¼ W.
S.S.E.	15¾ W.	S. 38¼ E.	N.N.W.	9¼ E.	N. 13¼ W.
S. by E.	11¼ W.	S. 22½ E.	N. by W.	7½ E.	N. 3¾ W.

When correcting for deviation *and* variation, separately, apply the deviation first, and then the variation.

RULE.—*To set a Correct Magnetic Course by the Deviation Table:*
Deviation *westerly*, allow it to the *right* of the compass course.
Deviation *easterly*, allow it to the *left* of the compass course.

To Correct the Compass for Variation.

Course by Compass given.	*True Course given.*
If variation east, allow to right.	If variation east, allow to left.
If variation west, allow to left.	If variation west, allow to right.
Will give true course.	*Will give magnetic course.*

To Correct the Course at once for Variation and Deviation.

If they are both of the same name, *i.e.*, both E or both W., add them together and apply their sum according to their joint name.

But if one be E. and the other W., take their difference, give it the name of the greater, and apply it according to that name.

EXAMPLE 1.—Compass course N.N.E. ; given, the deviation 8° 10′ E., and the variation 20° 10′ E., the sum thereof 28° 20′ E. being applied to the right hand of N.N.E., gives the true course N. 50° 50′ E.

EXAMPLE 2.—Suppose the deviation be still 8° 10′ E., but the variation of 20° 10′ W., their difference is 12° 0′ W., applied to the left hand, will give N. 10° 30′ E. for the true course.

REMARKS ON THE MARINER'S COMPASS.

A mariner's compass should possess as great *magnet power* as can be conferred upon it, almost perfect *sensibility*, and the maximum of steadiness. It has been found difficult to obtain an air or dry compass which should possess all these qualities, but the liquid compass has been so improved of late years as to combine them all to a fair degree.

Ritchie's Liquid Compass.

This is the regulation compass of the United States Navy, and consists of a skeleton card mounted on a pivot, and having the bowl filled with a liquid composed of thirty-five parts of alcohol and sixty-five parts of distilled water, the freezing-point of the mixture being about 10° Fahr. In the bowls of the compasses designed for use in the Arctic regions pure alcohol is used.

The needles, which are two in number, each consist of six laminæ of a superior quality of steel, known as "Stubb's sheet," this being selected on account of its uniform excellence, magnetic intensity, and permanence. Each of these laminæ is 6½ inches long, $\frac{7}{16}$ of an inch wide, and $\frac{1}{40}$ of an inch thick, and each needle weighs about two ounces.

These needles are enclosed in two parallel tubes, which are parallel to the N. and S. line of the card, their ends meeting the rim at a little within 30° of this line. These tubes are connected at the centre by a third tube at right angles to them, which supports the cap upon which the card is pivoted. The rim and tubes are air-chambers, giving great buoyancy to the card.

These compasses have given great satisfaction in use, and are found to possess in the highest degree the three great requisites of a good compass, viz.: *directive force*, *sensibility*, and *steadiness*. The 7½ inch has been adopted as the regulation size in the Navy.

The pressure on the pivot is on the average only 70 grains, and there is in conseqnence very little frictional error, and not much wear on the caps and pivots.

In the *tell-tale* compasses, which are mounted face downward, the pressure on the pivot is so regulated as to act upward.

Sir William Thomson's Compass.

This compass is designed to allow of easy adjustment for changes of deviation.

The card is supported on a thin rim of aluminium, and its inner parts on thirty-two silk threads, stretched from the rim to a central boss of aluminium. The card is of thin paper, having all the central portion cut away, leaving only an annular ring to show the points and degrees of the compass.

The central boss has a hole in its centre, which rests on an inverted aluminium cup mounted with a sapphire cap, which rests on a fixed iridium point.

Eight needles, from 3¼ to 2 inches long, made of steel wire, and weighing altogether 54 grains, are fixed like the rounds of a ladder on two parallel silk threads, and slung from the rim by four copper wires through eyes in the four ends of the outer pair of needles. For a ten-inch compass the whole weight on the iridium point is about 180 grains.

As the greater part of the weight of the card is at the rim, a long period of oscillation and consequent steadiness is insured. There is a hemispherical space under the compass-case, which, being filled with castor-oil, serves to calm the vibrations of the bowls.

The apparatus for compensation consists of two hollow iron globes placed on supports, and attached on two sides of the binnacle. These are for correcting the quadrantal error, and this adjustment once made remains correct in all latitudes, unless there is some change in the place of the iron near the compass. To make the correction the globes are placed at a certain distance from the centre of the compass sufficient to correct the deviation.

To correct the semicircular deviation, which changes with lapse of time and change of latitude, sets of magnets are so arranged in the binnacle as to neutralize this error, and also the heeling error. For this latter a vertical magnet, adjustable to the proper height, in a line through the centre of the compass and binnacle, is employed.

There is also a mirror by which bearings of objects on the horizon can be obtained and the readings taken directly on the card.

Duchemin's Compass.

This consists of two concentric magnetized circles or needles, with a steel traverse connecting the poles.

The maximum magnetization is at the north and south points, decreasing gradually to zero at east and west.

The circles are magnetized by a peculiar process, which gives magnetic stability, and when allowed to move freely it forms a true compass, the N. pole pointing to the south, and the S. pole to the north.

In a series of experiments made at sea with this compass, in which it was intentionally exposed to the roughest usage, it proved so satisfactory with regard to sensibility, steadiness, and fixity of the line of its poles, that it has been adopted as the regulation compass in the French Navy, and is in use in several lines of merchant steamers.

An Alarm Compass.

Mr. Henry A. Severn has invented a mariner's compass which enables the captain or officer in charge to hear, by the ringing of a bell, when the ship is out of the ordered course. Advantage has been taken of the constant position of the card and the ever-varying position of the ship, for the purpose of making and breaking metallic contact, which causes an electric bell to be sounded and so announce the fact that the vessel is off her course.

Over the card are two index hands, which can be adjusted at any angle so as to allow a given latitude in steering, either to port or starboard of the course. Should the ship be allowed to leave her course beyond the limit allowed on either side, the alarm-bell rings at once, and continues ringing until the right course is resumed. The compass can be used as an ordinary compass by raising the index hands away from the card, thereby disconnecting the bell.

The metal point upon which the card is pivoted is insulated from

the compass-bowl, and has attached to it a wire from one pole of a small battery.

About an inch above the card, placed parallel to its surface and attached to its metal centre, which is insulated from the needle, is an arm of metal reaching nearly to the edge of the card, which arm is, therefore, in metallic communication with the wire from the battery. The glass cover of the compass has a short brass rod working within a tube passing through it. These are attached to two brass milled heads above the glass, and to the two movable index hands beneath. These are in contact with the brass work of the compass, which is connected with the other pole of the battery. Beneath the outer extremities of the index hands are suspended two pieces of platinum wire about three-fourths of an inch long. By means of the two milled heads these hands can be moved over any point of the card, hence they admit of being placed on either side, and equally distant, or otherwise, from the metal arm on the card.

Thus, whenever the platinum wires come into contact with the metal arm on the card, the circuit is completed. The electric bell, being placed in the circuit, sounds whenever such contact takes place. To disconnect the bell, raise the milled head up half an inch through a sliding tube.

Two bells of different tone may be employed, and thus indicate whether the deviation is to port or starboard.

This arrangement is simple and compact, and would make a valuable "tell-tale" if placed in the cabin.

By its use headlands and dangers may be guarded against, while in the case of a vessel riding at anchor, or moored, the compass will, at once, give intimation of swinging—a matter of importance sometimes at night.

THE LOG-LINE AND TIME-GLASSES.

The apparatus commonly used for measuring the speed of a ship, consists of the *log-chip*, *log line*, *reel*, and 28 and 14 seconds *time-glasses*.

The log-chip is a flat piece of board, of a quadrantal form, of about eight inches radius, loaded on the circular edge with lead to make it float upright in the water. Small holes are bored at the corners, and through the two near the extremities of the arc are rove the

ends of a bit of small line about four feet long; these ends have a knot made in them to prevent their becoming unrove. To the middle of the line is seized a wooden plug or toggle.

The log-line is a small line about one hundred and fifty fathoms long, the end of which is taken through the remaining hole in the chip and knotted; on this line, at about the distance from the log-chip that the toggle is secured on the line first attached, is fastened a piece of wood with a socket into which the toggle fits. The whole is so arranged that when the toggle is in the socket the chip will float upright in the water. A sharp, quick pull on the line will always free the toggle, when the chip will fall flat on the water and may be easily hauled on board. The other end of the log-line is made fast to a reel, so arranged as to turn with as little friction as possible, and the line is then wound upon the reel clear for running.

The Time-Glasses.—These are ordinary sand-glasses running to seconds. The quantity of sand in the glass should be such that it will require exactly twenty-eight seconds of time in the "*long glass*," and fourteen seconds in the "*short glass*," to run into the lower bulb when the glass is held vertically. As the glasses may be affected by variation in the temperature, and the sand certainly by damp weather, it is necessary to examine their accuracy, from time to time, by comparing them with a seconds watch; they can be made true by drying the sand or changing its quantity, or the error may be allowed for.

To Mark the Log-line.—The line should be well soaked in water and stretched to clear it of any kinks, then a distance of from ten to twenty fathoms is measured from the chip and a piece of white rag is inserted. This marks what is termed the *stray line*, and is allowed to let the chip float well clear of the eddies astern of the vessel before commencing to reckon the speed.

The log-line is divided into distances termed *knots*, and these are subdivided into five parts, so that each subdivision represents two-tenths of a knot.

The length of a knot is taken as the same part of a nautical mile (6086.4 feet) that twenty-eight seconds is of an hour, which gives for its length 47.4 feet.

Measure from the white rag the length of the first knot, and mark it by twisting into the line, at that point, a small piece of cord with

one knot made in the end. Measure the length of the next knot from this mark, and insert a piece of cord with two knots in the end. Mark the next with three knots, and so on until the line is marked. Next subdivide each knot into five equal parts, marking them with small pieces of fish-line without knots.

Log-lines should be frequently examined and the marks verified, therefore, to facilitate this, the proper length of a knot and its subdivisions should be laid off on the quarter-deck, and marked by driving in copper tacks.

The line should invariably be wet when the marks are verified.

NOTE.—The log-line, no less than the glass, varies in its indications; especially does it contract by wetting. It may be considered that, one being correct, and the other faulty:

For error of seconds-glass—Glass too short gives distance too short;
Glass too long gives distance too long.
For error on log-line—Knot too short gives distance too long;
Knot too long gives distance too short.

If BOTH are *faulty*:—Multiply faulty length of knot by erroneous distance, and divide product by faulty time-glass runs; three-fifths of the result gives *true* distance.

Heaving the Log.—The log should be hove from the lee-quarter of a sailing vessel, or from a convenient place near the stern of a steamer.

One hand holds the reel, so that the line will have a clear run; another the time-glass; and an officer of the watch adjusts the chip by putting the toggle into its socket on the line, then takes the chip and a small coil of the line in his hand and sees all clear. When ready, he calls out to the glass-holder, "*Clear Glass?*" to which the latter, when the sand is all in one bulb, and he is ready, replies, "*All Clear!*"

The officer then calls out "*Look out!*" and heaves the chip over the taffrail, clear of the eddies, and assists the line off the reel by easy pulls in order to overcome friction; as the white rag marking the end of the stray line passes the taffrail, he calls out "*Turn!*" which the glass-holder repeats, at the same time turning the glass so that the bulb having the sand in is uppermost, and the sand runs into the lower bulb. When the sand is nearly out, the glass-holder calls out "*Stand by!*" and the instant it is out of the upper bulb,

he calls "*Out!*" The line is checked, and the mark on a line with the taffrail noted, or if there is no mark at the taffrail the nearest is noted and the speed estimated from it to the nearest tenth of a knot. A sharp pull on the line will free the chip, when the line is hauled on board and reeled up for the next heave.

The fourteen second glass is used when the speed of the vessel is above five knots, and in such case the speed shown by the line must be *doubled* to get the actual speed.

It is customary on board of men-of-war under way to heave the log at the end of every hour, and record the speed of the vessel in the log-book.

Care and skill are required to obtain a reliable result. A following sea will send the ship home and the speed shown will be too small. A head sea will cause the indication to be too great.

In a sailing vessel, if the wind be squally or variable, so that the speed will not be uniform thr ughout the hour, the log may be hove more frequently and an average taken as the speed for the hour.

Patent Logs.—Several patent logs are in general use, taking their names from their inventors, as Massey's, Reynold's, Trowbridge's, Walker's, etc. All of these are nearly alike in principle, and a general description will suffice for all.

They consist of an elongated metal box, containing a system of cog-wheels connected with the hands of three dials showing on the outside. To the rear of the box is attached a hollow cylinder, on which is a small propeller (termed the rotator or fly), whose shaft passes through the cylinder and connects with the cog-wheel work.

The pitch of the propeller is known, and consequently the number of revolutions it will make in a mile, which revolutions are registered by the cog-wheel system on the dials, one of which has the circumference representing 1 mile divided into tenths, the next representing 10 miles divided into tenths, and the last representing 300 miles divided into thirtieths, so that they will show readings from one-tenth of a mile up to 300 miles.

These logs are towed astern of the vessel by a stout line of 50 or 60 fathom in length, made fast to a swivel in the forward end, so that the rotation of the log will not twist the line.

Before using the logs, the hands of all the dials are set at 0, the log made fast to the towing-line and placed overboard astern. The *log is hauled in, and* the reading noted, whenever the course is

changed, angles are taken, etc., but should be reset only after 24 hours have elapsed. Under three knots the indications are not reliable, as the log does not float horizontally.

Patent logs must be hauled in when the vessel stops or goes astern, and care must be exercised to prevent the line getting foul of the propeller.

Taffrail Patent Log.—The principle of this log is the same as in the preceding ones, only the cog-wheel work, with its dials, is attached upon a convenient place on the taffrail, and the propeller towed overboard from it by a line through which its motion is communicated to the register. This obviates the necessity of hauling in the line each time a reading is desired, and only the propeller part is liable to be lost.

A small bell is sometimes attached to the register, which rings automatically at each mile passed over.

The Clark Russell, or Spring Log, consists of a spring balance attached to the taffrail, to which a line and float are attached. The pressures exerted upon the float when it is towed through the water at different rates of speed are determined by experiment, and these pressures in pounds form the scale to which the log is graduated.

The float is towed by means of a line attached to a hook at the end of the spring by a loop, and whenever it is desired to ascertain the speed of the vessel, the line is looped to the hook; the speed is then read off from the scale of the spring. If the float is kept towing all the time, the loop should be made fast to a hook on the taffrail and only looped to the spring when a reading is desired. This log does not give the distance run, but only the speed at the time it is used.

Ground Log.—In shoal water and currents, the actual run of the vessel over the ground is often wanted; to find this, the log-line is made fast to a lead, and the speed is measured in a similar way to that before described.

Current Logs.—This is the ordinary log used from a ship at anchor to determine the direction and velocity of currents. The result given will be the number of knots and tenths the current runs per hour, and the bearing of the chip will give the direction of the current. *Patent logs are often* used for this purpose.

LEAD AND LEAD-LINE.

The lead is generally made of prismatic shape, tapering to the upper end, through which a hole is made for a strap, to which is attached a marked line.

There are three classes of leads in use: the hand lead, weighing from 7 to 14 pounds, and from 6 to 10 inches in length; the coasting lead, weighing from 25 to 50 pounds, and about 18 inches long; and the deep-sea (*dipsey*) lead, weighing from 75 to 120 pounds, and about 2 feet long. The line used with the hand lead is about 30 fathoms long, and is used in depths of 25 fathoms and under; that of the coasting lead 120 fathoms long, and used in water from 25 to 100 fathoms in depth; and of the deep-sea lead 300 fathoms, and used in depths of over 100 fathoms.

THE HAND LEAD-LINE is marked at every two or three fathoms, so that the depth of water may be quickly ascertained; it is said to have *nine marks* and *eleven deeps*—the latter not being indicated by marks; they are as follows:

Fathom Deeps.		Fathom Marks.
1		
	2	Leather, two strips.
	3	Leather, three strips.
4		
	5	*White* calico.
6		
	7	*Red* bunting.
8		
9		
	10	Leather, with a hole in it.
11		
12		
	13	*Blue* serge.
14		
	15	*White* calico.
16		
	17	*Red* bunting.
18		
19		
	20	Strand, with two knots in it.

Calico, bunting, and serge are preferred as distinctive marks, because a man can tell the difference in the dark by the feel.

The line is always marked from the heel of the lead, and should be well stretched before marking.

A toggle is inserted at about a fathom from the lead, for the leadsman to handle it by.

A hand lead from three to five pounds in weight, with a light line marked to feet, is used from boats for running lines of soundings in shoal water.

Yachts and small craft sometimes have light hand leads with but ten or fifteen fathoms of line.

THE COASTING AND DEEP-SEA LEAD-LINES are both marked alike, viz.: at 10 fathoms, one knot; at 20 fathoms, two knots; at 30 fathoms, three knots; at 40 fathoms, four knots; and so on; and the intermediate fives are marked by small strands with one knot (or with no knots). At 100 fathoms a piece of red bunting is inserted, the knots are then marked as in the first hundred fathoms; at 200 fathoms a piece of white, and at 300 fathoms a piece of blue is inserted.

Heaving the Lead.

HAND LEAD.—The leadsman is placed generally in the main chains of the vessel, or at any convenient place where he can have a good foothold and a clear swing, with a broad breastband fastened at both ends, to prevent him from falling overboard. From this breastband down, a tarpaulin is generally used to protect the leadsman from the drippings of the line. The end of the lead-line is made fast near at hand.

The leadsman takes a coil of line in his left hand, holding it all clear for running, and in the other hand the line at the toggle, swings the lead to and fro until it has sufficient velocity to carry the line out, when he lets it go in the direction in which the vessel is moving, letting the lead take the line from the coil so that, when the line is up and down, as the leadsman arrives at the spot where the lead reached the water he can feel if the lead has touched bottom. The mark at the water's surface may be noted, or the depth estimated, from the nearest mark.

All the fathoms marked on the line are called "*marks*," and those not marked "*deeps*," *and these terms* are used by leadsmen in report-

ing soundings. For example, if the depth were 3 fathoms, it would be reported as "*by the mark* 3;" if 4 fathoms, as "*by the deep* 4;" if 3½ fathoms, as "*and a half* 3;" if 3¾ fathoms, as "*quarter less* 4." If no bottom is reached, as "*no bottom*" at so many fathoms.

When a vessel is going over six knots, it is difficult to obtain soundings in depths greater than 10 fathoms, and then the lead must be whirled round the head to give it sufficient velocity to carry the line well forward (ahead).

BY THE COASTING AND DEEP-SEA LEADS.—These leads have a hollow in the lower end which is always filled with clean tallow, or, as it is termed, "*armed*," before being cast. If the lead reach the bottom, it is known by a sample sticking to the tallow, which also serves to indicate the character of the bottom.

To get an accurate sounding with these leads, it is necessary to reduce the speed of the vessel, and if the water is deep to stop her way entirely, which is done by "*luffing up*" or "*heaving to*" in a sailing vessel, or by stopping and backing the engines in a steamer.

The "*armed*" lead is taken to the bows, and a sufficient number of the crew are arranged outside along the weather-side of the vessel.

The line, wound up on a reel, is placed at the stern; the end rove through a snatch-block made fast in a convenient place aft; carried forward outside of everything, and made fast to the lead.

Each man takes a coil of the line in his hand, and keeps it clear for running.

When the vessel's way has been sufficiently checked, the order is given "*Stand by!*" "*Heave!*" The lead is then *cast*, the person doing it at the same time calling out "*Watch-oh-watch!*" As the lead sinks, each man allows the line to run from his hand so that he can feel if the lead reaches the bottom, in which case he calls out "*Bottom!*" when the mark is noted and the line hauled in.

If no bottom is felt as the last of the line leaves the man's hand, he calls out to the next man aft, "*Watch-oh-watch!*" and so on to the stern, where the rest of the line may be allowed to run off the reel, observing if the lead touch bottom, which may be known by the line slacking. The line is then manned and hauled in, the depth and character of the bottom noted, and the vessel resumes her way.

In heavy weather it is better to take the line round the stern, outside from the weather-side, and heave the lead from the lee-side, so that by the time it has run out it will be nearly up and down, the ship's drift to leeward bringing her over the lead while the line is running out.

Sometimes a buoy and nipper (Burt's) is used to insure an up and down cast. The line is run through a spring catch on the buoy, which is thrown overboard with the lead; the line will run through the nipper as long as the weight of the lead is felt, but when the lead reaches the bottom, the spring of the nipper will catch and hold the line, so that the depth may be measured.

The above methods are used to obtain soundings for the purpose of determining the position of the vessel whenever necessary, but for surveying and scientific purposes finer work is needed.

A lead coming into general use is Thompson's pressure lead, which consists of a glass tube fitted into a lead, so as to give free access to the water at its lower end. This tube has a chemical preparation on the inside, which the water discolors as it rises in the interior, which it will do in proportion to the depth the lead descends, and this depth can then readily be determined from the length of the discolored portion of the tube.

Sounding-Machines.

Several machines have been invented to facilitate sounding, which take the name of the inventors, as *Massey's*, *Walker's*, *Ericsson's*, *Trowbridge's*, etc., but none are in general use.

SIR WILLIAM THOMSON'S SOUNDING-MACHINE.—This machine is designed to ascertain quickly and accurately the depth of water without stopping the vessel.

The apparatus consists of a wheel on which is wound about 300 fathoms of steel piano-forte wire. A stand, to which the supports of the wheel are attached, is fixed to the taffrail at the stern of the vessel, so that the sinker can hang clear for a cast.

A self-acting brake is arranged by a cord wound round a groove in the circumference of the drum, which, when the sinker is hanging, offers resistance enough to prevent its running down, but when it is being hauled in offers very little resistance to the turning of the wheel.

When ready to take a sounding, the brake is released by hand, so as to leave a force of about 7 pounds pulling on the rope, by which a resistance of about 5 pounds is opposed to the wire while it is running out. Thus, when the sinker reaches the bottom the wheel stops. The brake is then applied to prevent it from running on again.

The sinker is a long weight of 22 pounds, with a hollow at the bottom to receive the arming of tallow. It is attached to the end of the wire by means of a rope about 6 feet long, to which a brass tube about 2 feet long is seized. A glass tube 2 feet long, coated inside with *chromate of silver*, and open at one end only, is placed, with the open end downward, in the brass tube. As the sinker descends, the increased pressure drives the water up the glass tube, which, combining with the chromate of silver, produces a white mark, and this mark registers the height to which the liquor has been forced up the tube. A graduated scale shows at once the depth which has been reached.

The advantages of wire over rope of the same strength, are the smallness of area and smoothness of surface, and consequent small resistance when passing through the water. This permits the sinker to descend rapidly, and to be hauled on board again with ease. Two men can take soundings in 100 fathoms every few minutes, from a vessel going at any ordinary speed.

The drum when not in use is to be kept in a tank, and covered with lime-water or oil.

SIGSBEE'S SOUNDING-MACHINE.—The reel is practically the same as that in the Thomson apparatus, and a little in advance of it are two parallel pipes, about 6 feet in height, each containing an extension spring fastened at the bottom and connecting, by means of ropes leading over pulleys at the top of the pipes, with a cross-head free to move between the pipes, which serve as guides. The cross-head has a pulley 3 feet in circumference, over which the wire leads in its passage from the reel to the water.

The normal position of the cross-head is at the top of the guides, and the springs resist its being borne down. By this means a sensitive accumulator is arranged, which eases the jerks on the wire while reeling in, and also shows, by means of a graduated scale on the pipes, the amount of strain on the wire at any time during the

operation, thus acting as a dynamometer. An odometer, attached to the axle of the cross-head pulley, gives at once the number of yards of wire payed out or reeled in.

In paying out, no weights are required for tightening the friction line, as the latter is connected with the cross-head, and the resistance of the springs is made to serve that purpose. This arrangement acts also as an automatic governor on the motion of the reel when paying out wire in a seaway.

At the instant the sinker reaches the bottom, the resistance upon the reel is automatically increased.

The machine is almost entirely of steel, and has a small steam-engine attached.

THE QUADRANT AND SEXTANT.

The reflecting instruments which are in most common use at sea are the Quadrant and Sextant.

The Quadrant contains an arc of something more than 45°, and measures a few degrees more than 90°; it is generally made of wood, and the graduated arc, which is ivory, reads to minutes, and sometimes to 30″. The quadrant serves for common purposes at sea, but the sextant is required for accurate work, and is in general use.

The Sextant is made of brass, measures a few degrees more than 120°, and sometimes reads to 10″.

TO TAKE THE SUN'S ALTITUDE AT SEA.—Set the index at 0, put down a screen before the central mirror, hold the instrument in a vertical position, and direct the sight, through the sight-vane and horizon glass, to that part of the horizon which is exactly under the sun. Now move the index on with the left hand, and the image of the sun will appear to descend toward the horizon. Vibrate the instrument around the line of sight, and make the lower limb graze the horizon, this gives the *observed altitude* of the lower limb.

This is often near enough; but for accuracy, having made a rough contact as above, put in the telescope, previously set to distinct vision by looking through it at the horizon; the image being now magnified, the contact is made more correctly.

The contact should be made in the centre of the field; if it is not, the angle will be too great.

When there is a tangent screw, clamp the index, and make the contact perfect by turning the screw.

The observer acquires by experience the power of estimating the proper angle at which to set the index for a rough contact, and thus saves time. It also effects a saving of time to have the tubes of the telescope marked at the observer's focus.

When the angular distance between two objects is to be measured, the plane of the instrument is held in the line joining them, and the sight is directed to the fainter of the two. Therefore, when the brighter object is to the right, the instrument is held face upwards, and the image of the right hand object brought to touch the left hand object seen directly; but when the brighter object is to the left, the instrument must be held face downward, the sight being directed to the right hand object.

READING OFF THE ANGLE.—The arc being divided into degrees, and these subdivided into thirds, fourths, etc., each division contains several minutes, and the angle measured can therefore be read but roughly from the arc itself.

In order to obtain the reading to a fraction of a minute, a scale, called a *vernier*, is used; this is a portion of an arc, having the same radius and divided into *one part more* than an equal portion of the arc of the sextant.

The manner in which a more minute reading is obtained may be understood from the following: Suppose a division on the arc to be one-third of 1°, or 20′; and the vernier to be equal in length to 19 divisions, or 380′, but divided into 20 equal parts; then each division of the vernier is $\frac{1}{20}$ of 380′ or 19′, and therefore the difference between one division on the arc and one of the vernier is 1′.

Suppose the beginning, or 0, of the vernier and that of the arc to coincide, then the first of the dividing lines of the vernier falls short of the first dividing line of the arc by 1′; therefore, if we make these lines coincide we advance the vernier 1′. Again, to make the second dividing lines of each coincide we must move the vernier through 2′, and so on.

Adjustments.

I. The Index Glass, or central mirror, *must be perpendicular to the plane of the instrument.*

Set the index about 60°, then, if the image of the arc in the mirror appear in perfect continuation with the arc itself, the adjustment is perfect; if the reflection appear to droop from the arc itself, the mirror leans back; if it rise upward, the mirror leans forward. This adjustment generally rests with the maker, but may be rectified by the screws on the back.

II. The Horizon Glass, or fixed mirror, must be perpendicular to the plane of the instrument.

Set the index to 0, hold the instrument horizontally, look through the glass at the sea horizon or other distant object, and give the instrument a small nodding motion, then if the reflected image appear to coincide with the real object, the adjustment is perfect; if the *image* be the *lower*, the glass leans *forward*; if it be the *higher*, the glass leans *backward.* The position is rectified by the screws.

III. The line of sight of the telescope must be parallel to the plane of the instrument in which the index moves.

Place the two wires of the telescope parallel to the plane of the instrument. Select two distant objects from 100° to 120° apart, as the sun and moon, or two stars, and make an accurate contact at the wire nearest the instrument. Now move the instrument so as to throw the images in contact upon the other wire; if the contact is still perfect, the adjustment is perfect; if they have separated, the object end of the telescope droops; if they overlap, it rises. The position is rectified by the screws in the collar. When this adjustment is defective, the observed angle is always too great.

Index Error.—The graduation of the arc should begin at a certain point; when this is not the case the *index error*, as it is called, must be obtained.

The point at which the graduation of the arc should begin is that at which the index stands when the mirrors are parallel, as is the case when the image of a distant object is seen to coincide with the object seen directly. It is, therefore, the error of the place of the *beginning* of the graduation and affects all angles alike.

To Find the Index Error.

I. BY THE HORIZON.—Hold the instrument vertically, and make the image of the horizon *coincide* with the horizon itself as accurately as *possible. If the zero of* the index now coincide with 0 on

the arc, there is no index error; if it stands *on* the arc, the index correction is so much *subtractive*; if *off* the arc, *additive*. This index correction is to be frequently verified, and must be applied to all angles measured.

II. BY THE SUN.—Measure the sun's horizontal diameter (the vertical diameter being more affected by refraction), moving the index forward on the arc, and read off the measure, which will evidently be *on* the arc; then cause the images to change sides by moving the index back, take the measure again and read off; this reading will be *off* the arc; half the difference of the two readings is the index correction. When the diameter *on* the arc is the *greater*, the correction is *subtractive*; when the *lesser*, *additive*. If both readings are on the arc, which may occur with a very large index error, the index correction is the mean, and subtractive; if off, additive. One-fourth of the sum of the two readings should be equal to the sun's semidiameter in the "Nautical Almanac."

On account of the elasticity or spring of the index bar, the error may be different for the *forward* and for the *backward* motion of the index. It is well, therefore, to turn the tangent screw right and left alternately in making successive contacts, thus obtaining a partial compensation. This source of error may, however, be obviated by taking all observations, including that for index error, with the *forward* motion of the index bar, employing the tangent screw to close the reflected image and the object seen directly.

The adjusting screws should never be touched, except from necessity. It is better that error should exist, provided that it is allowed for, than that mischief should result to the instrument from attempts at a perfect adjustment. When two screws work against each other, care must be taken in tightening one to loosen the other if necessary.

LIGHTS.

The lights used in light-houses are divided into two general classes, Fixed and Variable. The fixed light maintains the same appearance; the variable lights change—some alternating by degrees between bright and dim, some flashing more or less suddenly, and others intermitting altogether.

Variable lights are distinguished from each other, also, by the dif-

ferent intervals of time in which the changes succeed each other, the effect of such changes being commonly produced by a revolving motion.

Color is also employed as a means of distinction.

Every light which varies its lustre is liable, when seen from a distance, to become altogether invisible during the period of lesser brilliancy; hence, a revolving light may seem to intermit.

Elevated lights are often entirely obscured by clouds.

As objects painted white are often lost sight of in a fog, while objects of a red color remain visible, buildings serving as marks for sailors are usually painted with red and white bands. Light-houses, therefore, being also useful as guides by day, are freqently painted in order to answer this purpose.

Systems.—Two systems are in general use, viz.: the *catoptric* and the *dioptric*, the former being produced by Argand oil-burners shown in the focus of a system of paraboloidal silvered metal reflectors, of which from one to ten may be used in the same plane, as the power and range may require.

In the dioptric system, the light is produced from one central oil-burner placed in the focus of a glass instrument, by which all the rays emanating from the sections of the flame best suited for the purpose are bent, so as to be sent nearly horizontally, and only to the sea's surface.

THE CATADIOPTRIC SYSTEM is a combination of the two preceding systems. Both of these systems admit of lights being shown as fixed, revolving, or flashing, and of various orders, determined in the catadioptric by the number of lamps and reflectors, and in the dioptric by the size of the instument and the corresponding central flame.

The magneto-electric light belongs to the dioptric class, the light being shown from an apparatus of that character.

Each of the systems above-mentioned presents some conditions which give it a superiority over the other, and these conditions are briefly as follows:

A CATOPTRIC REVOLVING LIGHT may, according to the number of reflectors used, be deemed equal to a dioptric light. Where, however, there are ten reflectors on a face, the great volume of light with a slow revolution has a superiority over the intensified flame of the

lens; it illumines to a greater extent the atmosphere; and thus has an advantage, especially where there is a haze.

This system has the further advantage over the dioptric of facility in erection at a distance from where skilled mechanics are obtainable, requiring less delicacy in putting up and focusing the lights, and being less liable to be put out of adjustment by volcanic or other disturbances.

It has also the advantage that its first cost is not more than half that of a dioptric light; and its consumption of oil and stores, except in the case of ten reflectors on a face, is not more than that of the lenticular light.

The power of a reflector is much increased by what is termed the "holophotal arrangement," where an annular lens is placed in front of the frame, while all the back rays of light, which are otherwise lost, are thrown back into the flame by a hemispherical mirror. Three reflectors of this kind to a face make an excellent revolving light.

In a CATOPTRIC FIXED LIGHT, the reflectors (with an Argand lamp in the focus of each) are arranged round a circular frame, and if intended to illuminate the entire horizon there are generally thirteen in each tier; those in the second tier being placed over the interstices of the other, so as to produce an equal distribution of light. The reflectors generally used are 21 inches in diameter at the lips, and the Argand burner seven-eighths of an inch.

For a *fixed* light, the catoptric is far inferior to the dioptric system, and is only used for lights of that character in positions where want of importance does not warrant the use of a lens. It possesses one advantage, in that it is not in the same degree subject to deterioration for want of care and skill on the part of the attendants.

In a catoptric revolving light, the reflectors are grouped together, with their axes parallel to each other on three or more faces, so as to throw their combined light in one direction.

The number of faces depend upon the rapidity of revolution and length of the flash intended to be given; but where the interval amounts to half a minute or more there are generally only three faces, which may each contain one or more reflectors.

DIOPTRIC LIGHTS, whether fixed, revolving, or flashing, vary in the size of the lamp and apparatus, according to the order required, and are numbered from 1 to 6. The 1st, 2d, and 3d orders are all

used for coast illumination; the 4th, 5th, and 6th order lights are usually employed at the entrance of harbors, or as lower leading lights.

As a fixed light, the dioptric possesses many advantages over the catoptric, especially where it is required to illumine the whole circle of 360 degrees. Over an arc, too, according to its area, it has the power of intensifying the light, by utilizing it where not required, and returning it from where it would be wasted otherwise, to strengthen the illuminated arc. It has also a great advantage over the reflector, in its facilities for marking channels or outlying dangers, which is done by placing a sector of colored glass vertically on the lens, in conjunction with one on the lantern glass, in line with the danger to be marked; and this can be done with an accuracy impossible in a catoptric light.

In a dioptric revolving light, the panels of glass usually range from eight to sixteen in number, but occasionally there are only six panels, which produces a very powerful flash by concentrating a larger arc of light.

Annual Consumption of Oil.—The Argand, or single wick, used in the 4th order dioptric lights, and in reflectors, consumes about forty-two gallons per lamp.

2-wick	burners,	small	size,	112	gallons	per	lamp.
2	"	large	"	214	"	"	"
3	"	"	"	412	"	"	"
4	"	"	"	828	"	"	"

Recently 5 and even 6-wick burners have been introduced. The burners consist of concentric wicks, alternating with concentric air-passages.

ILLUMINANTS.—Until lately the illuminants have consisted of animal or vegetable oils, chiefly rape oil, or what is known as Colza. In the United States lard oil is used; in the tropics cocoa-nut oil is used with advantage, and is said to attain a high degree of illumination.

Petroleum, kerosene, paraffin, and other mineral oils, have within a few years been introduced for the lower order lamps, with great advantage *both in economy* and power. They also have the advan-

tage of requiring no attention, as they burn steadily throughout the night without trimming.

Several of the Irish lights use gas made from Cannel coal. By an arrangement of concentric circles of jets, either one or more of which can be lighted (according to the state of the atmosphere), the number of jets may be increased from twenty-eight to one hundred and eight. The gas may be alternately turned on and off by automatic action, so as to produce an intermittent light of different intervals in a fixed apparatus, or flashes when the apparatus is revolving.

Apparent Light.—This is a very useful contrivance, by which beacons marking sunken rocks lying off light-houses may be illuminated, by reflection, from an apparatus, hermetically sealed, placed on top of the beacon.

The apparatus consists of a plane mirror, upon which the rays of light from the light-house impinge, the reflected rays being strengthened by passing through glass prisms.

This apparatus was first used at Stornoway, in the Hebrides, to illuminate the beacon on Arnish Rocks. They are three hundred and fifty feet distant from the special light, placed in a window in the lower part of the light-house on a level with the beacon.

Light-house Establishment of the United States.

THE LIGHT-HOUSE BOARD is composed of nine members: three officers of the navy, two of high rank; three officers of the corps of engineers of the army; and three civilians, one of whom is the Secretary of the Treasury, and the remaining two to be of high scientific attainments.

The Board has elevated the character of its personnel, and has succeeded in withdrawing the promotion and transfer of light-keepers, over a thousand in number, from politics, and making them depend on merit. It has provided small libraries, which pass from station to station, and it is intended to place the service on a still higher footing.

On July 1, 1880, the Light-house Establishment had in position 47 first order lights, 26 of the second order, 55 of the third order, 10 of the third and a half order, 204 of the fourth order, 288 of the fifth

and sixth orders; 24 lanterns and lenses; 31 light-ships; 57 fog-signals, operated by steam or hot air; 25 automatic whistling-buoys; numerous day beacons; and 3,115 other buoys; also 819 stake-lights on the western rivers.

The coasts of the Atlantic, the Gulf of Mexico, the Pacific, and the great northern lakes, are divided into twelve districts, and the western rivers into two districts, as follows:

First District.

The first district extends from the northeastern boundary of the United States, Maine, to and including Hampton Harbor, New Hampshire, and includes all aids to navigation on the coasts of Maine and New Hampshire.

Second District.

The second light-house district extends from Hampton Harbor, New Hampshire, to include Gooseberry Point, entrance to Buzzard's Bay, and embraces all the aids to navigation on the coast of Massachusetts.

Third District.

The third district extends from Gooseberry Point, Mass., to include Squam Inlet, N. J., and embraces all the aids to navigation on the sea and sound coasts of Rhode Island, Connecticut, and New York, Narragansett and New York Bays, Providence and Hudson Rivers, Whitehall Narrows, and Lake Champlain.

Fourth District.

The fourth light-house district extends from Squam Inlet, N. J., to and including Metomkin Inlet, Va. It includes the sea-coast of New Jersey below the Highlands of Navesink, the bay-coasts of New Jersey and Delaware, the sea-coasts of Delaware and Maryland, and part of the sea-coast of Virginia.

FIFTH DISTRICT.

The fifth light-house district extends from Metomkin Inlet, Va., to include New River Inlet, N. C., and embraces part of the sea-coast of Virginia and North Carolina, Chesapeake Bay, Sounds of North Carolina, and the James and Potomac Rivers.

SIXTH DISTRICT.

The sixth district extends from New River Inlet, N. C., to and including Cape Canaveral light-house, Florida, and embraces part of the coast of North Carolina, the coasts of South Carolina and Georgia, and part of the coast of Florida.

SEVENTH DISTRICT.

The seventh light-house district extends from Cape Canaveral, on the eastern coast of Florida, to the Perdido River, on the Gulf coast, and embraces all the aids to navigation within those limits.

EIGHTH DISTRICT.

The eighth light-house district extends from the Perdido River, Fla., to the Rio Grande, Texas, and embraces the coasts of Alabama, Mississippi, Louisiana, and Texas.

TENTH DISTRICT.

The tenth district extends from the mouth of Saint Regis River. N. Y., to include Grassy Island light-house, Detroit River, Mich., and embraces all the aids to navigation on the American shores of Lakes Erie and Ontario, and Saint Lawrence River.

ELEVENTH DISTRICT.

The eleventh district embraces all aids to navigation on the northern and northwestern lakes above Grassy Island light-station, Detroit River, and includes Lakes Saint Clair, Huron, Michigan, and Superior, and the straits connecting them.

TWELFTH DISTRICT.

CALIFORNIA.

This district embraces all aids to navigation on the Pacific coast of the United States between the Mexican frontier and the southern boundary of Oregon, and includes the coast of California.

THIRTEENTH DISTRICT.

This district embraces all aids to navigation on the Pacific coast of the United States north of the southern boundary of Oregon. It extends from the forty-first parallel of latitude to British Columbia, and includes the coasts of Oregon and of Washington Territory.

FOURTEENTH DISTRICT.

The fourteenth light-house district extends from Pittsburg, Pa., to Cairo, Ill., and embraces all the aids to navigation on the Ohio River.

FIFTEENTH DISTRICT.

The fifteenth light-house district extends on the Mississippi from the head of navigation to New Orleans, and on the Missouri from the head of navigation to its mouth, and embraces all the aids to navigation within those limits.

BUOYS.

Buoyage on the Coast of the United States.

In conformity to the terms of the act of Congress approved September 28, 1850, describing the manner of coloring and numbering the buoys along the coasts and in the bays, sounds, rivers, and harbors of the United States, the following order is observed, viz.:

In approaching the channel, etc., from seaward, *red buoys with even numbers* will be *found on the starboard* side of the channel, and must be *left on the starboard* hand in passing in.

In approaching the channel, etc., from seaward, ***black buoys*** with *odd numbers* will be found on the ***port*** side of the channel, and must be left on the *port* hand in passing in.

Buoys painted with *red* and ***black horizontal stripes*** will be found on obstructions with channel-ways on either side of them, and may be left on either hand in passing in.

Buoys painted with *white* and ***black perpendicular stripes*** will be found in *mid-channel*, and must be passed close-to to avoid danger.

All other distinguishing marks to buoys will be in addition to the foregoing, and may be employed to mark particular spots.

Perches with balls, cages, etc., will, when placed, be at turning-points, the color and number indicating on which side they shall be passed.

Vessels approaching or passing light-vessels of the United States, *in thick, foggy weather*, will be warned of their proximity by the alternate ringing of a bell and sounding of a fog-horn on board of the light-vessel at intervals not exceeding five minutes.

Canada is buoyed on the same system.

England.

SYSTEM OF BUOYAGE IN USE BY THE CORPORATION OF TRINITY HOUSE IN BUOYING NEW CHANNELS.

The side of the channel is to be considered starboard or port with reference to the *entrance* to any port *from* seaward.

The entrance of channels or turning-points shall be marked by spiral buoys, with or without staff and globe, or triangle, cage, etc.

Single-colored can buoys, either black or red, will mark the ***starboard*** side, and buoys of the same shape and color, either checkered or vertically striped with white, will mark the ***port*** side; further distinction will be given, when required, by the use of spiral buoys, with or without staff and globe, or cage—globes being on the starboard hand and cages on the port hand.

Where a *middle* ground exists in a channel, each end of it will be marked by a buoy of the color in use in that channel, but with horizontal rings of white, and with or without staff and diamond or triangle, as may be desirable; in case of its being of such extent as to require intermediate buoys, they will be colored as if on the sides

of a channel. When required, the outer buoy will be marked by a staff and diamond, and the inner one by a staff and triangle.

Wrecks will still continue to be marked by green nun-buoys.

Coloring of Buoys.

As regards checkered buoys, each buoy, exclusive of the nozzle, is to be divided *horizontally* into four, and *vertically* into eight equal parts; but the white squares are then to be further reduced by one inch all round, being colored either in red or black, as the case may be.

As regards vertically striped buoys, each buoy is to be divided into eight parts, and each division is to be alternately colored red and white or black and white, but the white stripes are to be one-third narrower than the black or red.

As regards buoys colored in horizontal bands or stripes, each buoy is to be divided into five parts, which are to be colored red and white or black and white alternately, the white bands being one-third narrower than the black or red.

All buoys have their names painted on them in conspicuous letters.

Ireland.

By direction of the Trinity House, harbors, rivers, and channels are in future to be marked by either *black* or *red* buoys on the starboard hand when entering from the sea, and on the port hand by buoys of the same color as those on the starboard hand with the addition of a white belt; and middle dangers to be marked by *white* buoys surmounted by a *black* beacon.

Scotland.

SYSTEM ADOPTED BY THE COMMISSIONERS OF NORTHERN LIGHTHOUSES.

Entering port, etc., from seaward, *red buoys* must be left on the *starboard* hand *in passing in.*

Entering port, etc., from seaward, ***black buoys*** must be le *port* hand in passing in.

Buoys painted *red and black* are placed on detached dan; may be passed on either hand.

Fairway buoys are plainly marked. Wreck buoys are *green*.

All buoys have their names painted on them.

Liverpool is buoyed on the same system.

France.

On entering a channel from seaward, all buoys and beacon *red* with a *white* band near the summit must be left to st those painted *black* must be left to port; buoys that can b either side are colored *red* with *black horizontal bands*. Th a beacon *below* the level of *high water* and all warping b colored *white*. The small rocky heads in channels are color same way as the beacons, when they have a surface sufficie spicuous.

Each buoy has upon it the name of the danger it is mea tinguish; likewise its number, commencing from seaward. numbers are on the red buoys, and the odd numbers on the bla The letters and numbers are *white*, and from 10 to 12 length. All jettyheads and turrets are colored above half-ti and on the former a scale of *metres* is marked from the sa

Holland.

On entering the channel, etc., from seaward, *white buoys* left on the starboard hand, and *black buoys* on the port han

Belgium.

Same system as Holland.

Table Showing the Depth of Water in the Channels of Various Harbors, Rivers, and Anchorages on the Coast of the United States.

[*Coast Survey.*]

ATLANTIC COAST.

Harbor.	Location.	Feet.	
Kennebec River	Up to Hanniwell's Point	25 5	33.6
Portland, Me.	Breakwater to Anchorage	16	24.9
	Channel off Town	27	35.9
Portsmouth, N. H.	Narrows to the City	45	53.5
Newburyport	Bar	7	14.8
Ipswich	Bar	7.5	16.1
Annisquam	Bar	6.5	15.5
Gloucester	Channel to S. E. Harbor	30	38.9
	Up into Inner Harbor	24	32.9
Salem, Mass.	Southern Ship Channel	28	37.2
	Inside of Salem Neck	19	28.2
Boston, Mass.	Channel, Lovell's and Galop's Islands	28.5	38.5
	Channel, Governor's and Castle Islands	18	28
Plymouth	Up to Anchorage	14	24.2
	Anchorage in the Cow Yard	24	34.2
Barnstable Harbor	Bar	7.7	17
Newport, R. I.	Anchorage S. and W. of Goat Island	33	36.9
	Wharves inside of Goat Island	21	24.9
	Newport to Prudence Island	31	34.9
	Mount Hope Bay	42	45.9
New York	Gedney's Channel	23	27.8
	Swash Channel	17	21.8
	South Channel	21	25.8
	Main Channel	31	35.8
	Ship Channel, after passing S. W. Spit buoy	23	27.8
Arthur's Kill	Anchorage, Perth Amboy	22	26.9
	Woodbridge to Rossville	13.5	18.6
	Rossville to Chelsea	14	19.1
	Chelsea, Western Channel, to Elizabethport	13	18.1
	Elizabethport to Shooter's Island	6.5	10.9
Kill von Kull	Shooter's Island to Bergen Point L. H.	10	14.3
	Bergen Point L. H. to New Brighton	27	31.3
Newark Bay	Bergen Point L. H. to mouth of Hackensack R.	7	11.6
Hudson River	Castle Garden to Manhattanville	32	36.
	Manhattanville to Yonkers	27	30.8
	Yonkers to Piermont	39	42.5
	Piermont Ferry to Sing Sing	24.5	28.

Table Showing Depth of Water.—*Continued.*

Harbor.	Location.	Fee
Hudson River	Sing Sing to Haverstraw	26
	Haverstraw to Peekskill	27
Delaware Bay	Main Channel, passing Delaware Breakwater	61
	Off Brandywine L. H.	43
	Main Channel to Bombay Hook L.	27.5
	Main Channel, Liston's Point	20
Delaware River	Main Channel to Reedy Island	20
	Main Channel, Reedy Island L. H.	24.5
	Opposite Delaware City	30
	Up to Marcus Hook	20.5
	Opposite Chester	24.5
	Bar off Hog Island	18.5
	Greenwich Point to Philadelphia	21.5
Chesapeake Bay	Capes at Entrance to Hampton Roads	30
	Anchorage, Hampton Roads	59
	Hampton Roads to Sewell's Point	25
	S. of Sewell's Point (one mile and a half)	21
	Up to Norfolk	23
	Hampton Roads to James River	27
Potomac River		
York River, Va.	Tail of York Spit to Yorktown	33
James River, Va.	White Shoal Bar	16
	Up to Jamestown Island Bar	19
	Channel to one mile above deep water L. H.	23
	Jamestown Island Bar	15
	Harrison's Bar	13.5
	Trent's Reach	8.5
	Warwick Bar	12.5
	Richmond Bar	7
Elizabeth River, Va.	Norfolk to Navy Yard	25.5
Hatteras Inlet, N. C.	Bar	14
	Over Bulkhead into Pamlico Sound	7
Acracoke Inlet	Bar	10
	Anchorage Wallico's Channel	19
Albemarle Sound	Light-boat off Carvou's Point	7
	Up the Sound to Martin's Point	5.5
North River, N. C.	At Entrance, and 7 miles up from Albemarle Sd.	6.7
Beaufort, N. C.	Main Channel	15
	Through the Slue	7
Cape Fear	New Inlet Bar	8
Georgetown, S. C.	Entrance to Winyah Bay	7
	Anchorage inside of North Island	27
	Up to Georgetown	9
Bull's Bay	Bar	13

Table Showing Depth of Water.—*Continued.*

Harbor.	Location.	Feet.	
Bull's Bay	Anchorage	21	25.8
Charleston, S. C.	Main Bar	11	16.1
	North Channel	10	15.1
	Maffit's Channel	11	16.1
Stone Inlet	Bar	6.5	12.5
North Edisto	Main Channel	12	17.8
St. Helena Sound	S. Channel	17	22.9
	S. Edisto	14	19.9
Port Royal	S. E. Channel	19.5	25.9
Tybee	Bar near Tybee Island	19	26
	Tybee Roads	31	38
Savannah	Channel up to City	11	17.5
Ossabaw Sound	S. Channel to Vernon River	12	18.6
	S. Channel to Ogeechee River	13	14.6
Sapelo Sound	Bar	18	25
Doboy Bar (Inlet)	Entrance over Bar	15.5	22.1
	Anchorage in Sound	24	30.6
St. Simon's Sound	Bar	15	21.8
	Entrance to Sound	38	44.8
	Turtle River to Blythe Island	21	27.8
	To Brunswick over Bar	9	15.8
	To Brunswick, Channel	13	19.8
St. Mary's	Bar	11	16.8
St. Andrew's Bay	Main Channel, Bar	13	14
Pensacola	Bar	22.5	23.5
	Bar to Navy Yard	27	28
	Wharf at Pensacola	21	22
Mobile Bay and River	Outer Bar	21	22
	Main Channel to Fort Morgan	36	37
	To Upper Fleet	12	13
Mississippi Sound	Grant's Pass to Pascagoula Wharf	7.5	8.7
	Horn Island Pass, over Bar	15	16.2
	Anchorage, Horn Island	19	20.2
	Up to Pascagoula Wharf	8	9.2
Ship Island Harbor	Channel	19	20.3
	N. W. Channel	19.5	20.8
	Anchorage	18	19.3
Cat Island Harbor	Ship Channel	16	17.3
	S. Pass	14	15.3
	Shell Bank Channel	15.2	16.5
Mississippi Delta	Pass à l'Outre, N. Channel	9.5	10.6
	S. Channel	12	13.1
Northeast Pass	*Over Bar N. Entrance*	9.5	10.6
Southeast Pass	*Entering*	10	11.1

Table Showing Depth of Water—*Continued.*

Harbor.	Location.	Feet.	
South Pass	Channel	8	9.1
Southwest Pass	Channel	15.5	16.6
St. John's River, Fla.	Bar	7	11.5
	Channel up to Jacksonville	23	25.1
St. Augustine	Bar	7	11.2
Florida Reef	Cape Florida L. H. W. S. W. ¼ W	20	21.5
	Turtle Harbor entrance	26	27.5
	Inside the Reefs. Hawk Channel	11	12.5
	Key Sambo Channel	34	35.3
Key West	Main Channel to middle buoy on Shoals	27	28.3
	Shoals to Anchorage	30	31.3
	Sand Key Channel	27	28.3
	W. Channel	30	31.3
Tortugas	N. W. Channel	45	46.2
	S. W. Channel	54	55.2
Tampa Bay	Bar	19	20.4
	Channel Egmont and Passage Keys	17	18.4
Waccasassa Bay	Channel to Anchorage	8	10.6
Cedar Keys	Main Channel over Bar	9	11.5
St. Mark's	Bar	9	11.5
	Up to Fort St. Mark's	7	9.5
St. George's Sound	E. entrance over Bar	15.5	17.1
	Anchorage	19	20.6
Apalachicola	Bar	13	14.1
	Up to Anchorage	10	11.1
Barrataria Bay	Bar of Grand Pass	7.5	8.7
	Grand Passage to Independence Island	15	16.2
Dernière or Last Island	Channel inside, and N. of Ship Isl'd Shoal, L. S.	27	28.4
	Channel N. of Ship Island Shoal	14	15.4
Atchafalaya Bay	Entrance to Cut-off Channel buoy	8	9.6
	Bulkhead	6.5	8.1
	Mouth of Atchafalaya River	48	49.6
Vermilion Bay	Mid-channel off L. H	42	43.6
Calcasien River	Entrance over Bar	5.5	7.4
Sabine Pass	Bar	7.5	9
Galveston Bay	Entrance over Bar	12	13.1
San Luis Pass	Bar	8	9.1
Brazos River	Bar	8	9.1
Matagorda Bay	Bar	9	10.1
Aransas Pass	Aransas Pass	9	10.1
Rio Grande	Channel	4	4.9

Table Showing Depth of Water.—*Continued.*

PACIFIC COAST.

Harbor.	Location.	Feet.	
San Diego Bay	Entrance	27.4	31.3
	Abreast of La Plaza	18	21.9
San Pedro	Point Pedro and Dead Man's Island	18	21.9
Point Duma	Anchorage	54	58
San Buenaventura	Anchorage	36	40
Santa Cruz Island	Anchorage, Prisoner's Harbor	75	79
Santa Barbara	Anchorage inside of Kelp	18	22
San Miguel Island	Cuyler's Harbor	37	41.1
Coxo Harbor	Anchorage	30	34
San Luis Obispo	Anchorage	33	36.8
San Simeon	Harbor Anchorage	24	27.8
Monterey Harbor	Anchorage	42	45.9
Santa Cruz Harbor	Anchorage	27	31.6
San Francisco Bay	From Four-fathom Bank to S. shore	28	32.1
	Rincon Point	66	70.1
	Market Street Wharf	54	58.1
	Cunningham's Wharf	36	40.1
San Francisco Harbor	On Bar	33	37.1
Mare Island Straits	Mid-channel	25	30.5
	Mid-channel, Navy Yard, and Vallejo	25	30.5
Ballenas Bay	Inside of Breakers, Duxbury Reef	24	28.1
Sir Francis Drake's Bay	Inside the Point	17	21.1
Tomales Bay	Bar	10	14.1
Bodega Bay	Inside of Reef, off Point	36	40.1
Coast	Haven's Anchorage	48	52.3
Albion River	Anchorage	48	52.4
Mendocino City	Anchorage	30	34.4
Shelter Cove	Anchorage	22	26.6
Humboldt Bay	Channel	20	24.7
Crescent City Harbor	Anchorage off City	21	26.2
Ewing Harbor	Anchorage	46	51.7
Koos Bay	Bar	11	16.7
Umpqua River	On Bar, opposite Mid-channel	13	19
Columbia River	N. Channel to Baker's Bay	24	30.5
	Entrance into S. Channel	19	25.5
	On Bar of S. Channel	16	22.5
Shoalwater Bay	On Bar	18	24.5
	S. Channel	25	31.5
Grenville Harbor	Anchorage	22	28.5
Neè-ah Harbor	Anchorage	38	42.5
False Dungeness	*Anchorage*	54	60.4
New Dungeness	*Anchorage*	45	51.4

Table Showing Depth of Water—*Continued.*

Harbor.	Location.	Feet.	
Smith's Island, N. side	Anchorage	25	31.4
Bellingham Bay	Anchorage	18	24.4
Port Townshend	Anchorage	48	54.4
Port Ludlow	Anchorage	36	42.4
Port Gamble	Anchorage	18	24.4
Seattle	Anchorage	20	28
Blakely Harbor	Anchorage	46	54
Steilacoom Harbor	Anchorage	18	29.5
Olympia Harbor	Mid-channel	11	22.5

Section 3.

WEATHER, BAROMETER, THERMOMETER, ETC.

WINDS, SQUALLS, REVOLVING STORMS,
HURRICANES, LAW OF STORMS,
ETC. ICE.

TIDES, TIDAL OBSERVATIONS, TIDE GAUGES, ETC.

CURRENT OBSERVATIONS. OCEAN CURRENTS.

HYDROGRAPHIC INFORMATION.

TO REDUCE SOUNDINGS TO LOW WATER.

MERIDIANS ADOPTED IN THE CONSTRUCTION OF
FOREIGN CHARTS.

HYDROGRAPHIC ABBREVIATIONS, ETC.

WEATHER.

SYMBOLS.

b represents	Blue sky.	*q* represents	Squally.
c "	Clouds (detached).	*r* "	Rain.
d "	Drizzling rain.	*s* "	Snow.
f "	Foggy.	*t* "	Thunder.
g "	Gloomy.	*u* "	Ugly (threatening).
h "	Hail.	*v* "	Visibility { objects at a distance very distinct.
l "	Lightning		
m "	Misty (hazy).		
o "	Overcast.	*w* "	Wet (dew).
p "	Passing showers.		

A bar (—) under any letter augments its signification: thus, $\underline{f}$ very foggy, $\underline{r}$ heavy rain, $\underline{\underline{r}}$ heavy and continuing rain.

General Remarks.*

COLOR OF SKY.

A few of the more marked signs of weather are the following:

A rosy sky at sunset presages fine weather; a sickly greenish hue —wind and rain; tawny or coppery clouds—wind; a dark (or Indian) red—rain; a red sky in the morning—fine weather; a high dawn—wind; a low dawn—fair weather; soft-looking or delicate clouds foretell fine weather, with moderate or light breezes; hard-edged, oily-looking clouds—wind. A dark gloomy blue sky is windy, but a bright blue sky indicates fine weather. Generally, the softer clouds look the less wind, but perhaps more rain may be expected; and the harder, more "greasy," tufted, rolled, or ragged, the stronger the coming wind will prove. Also, a light-yellow sky at sunset presages wind; a very pale yellow—wet; orange color—wind and rain; and thus the coming events may be very nearly foretold, and, if aided by instruments, almost exactly.

CLOUDS.

The scale generally adopted for denoting the amount of cloud is 0 to 10: 0 indicating a clear sky; 5, a sky half-covered; and 10, the sky wholly obscured.

* Portions of these remarks are extracted from Bedford's Pocket Book.

Light, delicate, quiet tints or colors, with soft indefinite forms o clouds, indicate and accompany fine weather; but gaudy or un usual hues, with hard, definitely outlined clouds, foretell rain, an probably strong wind.

Small inky-looking clouds foretell rain; light scud clouds drivin across heavy masses show wind and rain; but, if alone, may indicat wind only—proportionate to their motion.

High upper clouds crossing the sun, moon, or stars, in a directio different from that of the lower clouds, or the wind then felt below foretell a change of wind toward their direction.

After fine clear weather, the first signs in a sky of a comin change are usually light streaks, curls, wisps, or mottled patches c white distant cloud, which increase and are followed by an overcast ing of murky vapor that grows into cloudiness. This appearance more or less oily or watery, as wind or rain will prevail, is an infall ble sign.

Usually the higher and more distant such clouds seem to be, th more gradual, but general, the coming change of weather will prove

Misty clouds forming or hanging on heights, show wind and rai coming if they remain, increase, or descend. If they rise or dis perse, the weather will improve or become fine.

DESCRIPTION OF CLOUDS.

CIRRUS cloud consists of streaks, wisps, and fibres, vulgarl called "mare's tails," which may increase in any or all directions Of all clouds it has the least density, the greatest elevation, and th greatest variety of extent and direction, or figure.

It remains for a short time when found in the lower parts of th atmosphere and near other clouds, and longest when alone in th sky and at a great height. When streaks of cirrus run quite acros the sky in the direction in which a light wind happens to blow, th wind will probably soon blow hard, but remain steady. When th fine threads of the cirrus appear blown or brushed backward at on end, as if by a wind prevailing in these elevated regions, the win on the surface will ultimately veer round to that point.

CUMULUS, a cloud in dense convex heaps in rounded forms de finitely terminated above; the lower surface remains roughly hor zontal.

When of moderate height and size, of well-defined curved outline, and appearing only during the heat of the day, they indicate a continuance of fair weather. But when they increase with great rapidity, sink down to the lower parts of the atmosphere, and do not disappear toward evening, rain may be expected.

STRATUS is a continuous extended sheet of cloud, increasing from below upward. It is the lowest sort of cloud. It generally forms about sunset, grows denser during the night, and disappears about sunrise.

CIRRO-CUMULUS is composed of well-defined, small, rounded masses, lying near each other, and quite separated by intervals of sky. It is commonly known as a "mackerel sky;" it occurs frequently in summer, and is attendant on warm and dry weather.

CIRRO-STRATUS.—This cloud partakes partly of the characteristics of the cirrus and stratus. In distinguishing it, attention must be paid, not so much to the form, which is very variable, but to the structure, which is dense in the middle and thin toward the edges. It is a precursor of storms, and from its greater or less abundance and permanence, it gives some indication of the time when the storm may be expected.

CUMULO-STRATUS.—This cloud is formed by the cirro-stratus blending with the cumulus, either among its piled-up heaps, or spreading underneath its base as a horizontal layer of vapor.

CUMULO-CIRRO-STRATUS OR NIMBUS.—This is the *rain-cloud.* At a considerable height a sheet of cirro-stratus cloud is spread out, under which cumulus clouds drift from windward; these, rapidly increasing, unite at all points, forming one continuous mass, from which rain falls.

SCUD.—When a rain cloud is seen approaching at a distance, cirri appear to shoot out from its top in all directions, and it has been observed that the more copious the rainfall, the greater is the number of cirri thrown out from the cloud.

RAINBOWS.—"A rainbow in the morning—
Sailors take warning;
A rainbow at night
Is the sailor's delight."

Morning rainbows indicate the advance of rain-cloud from the west when it is clear in the east; and the fall of rain at the time of day when the temperature should be rising, is regarded as a prognostic of a change to wet, stormy weather.

On the contrary, the conditions under which a rainbow can appear in the evening are: the passing of the rain-cloud to the east, and a clearing up in the west at the time of day when the temperature has begun to fall, thus indicating a change from wet to dry weather.

"The evening gray and the morning red,
Put on your hat, or you'll wet your head."

This does not refer to a *high* red dawn, which may be regarded as a prognostic of settled weather. But if clouds be red and *lowering* later in the morning, it may be accepted as a sign of rain.

THE BAROMETER.

The barometer, feeling the pressure of the air, shows at once when that pressure is changing. If the pressure at one place on the earth's surface be greater than at another, the air has a tendency to move from the place where the pressure is greater, toward that where it is less, and thus *wind* is caused.

A change of weather comes almost always with a change of wind, and the extent of this change of weather depends on the fact of the new wind being warmer or colder, damper or drier, than that which has been blowing. Any conclusions drawn from its movements must be checked by observations of temperature, moisture of the air, present direction and force of wind, and state of the sky, before any correct opinion can be formed as to what may be expected. In general, whenever the level of the mercury continues steady, settled weather may be expected; but when it is unsteady a change must be looked for, and perhaps a gale.

A sudden rise of the barometer is very nearly as bad a sign as a sudden fall, because it shows that atmospherical equilibrium is unsteady. In an ordinary gale the wind often blows hardest when the barometer is just beginning to rise, directly after having been very low.

Besides these rules for the instrument, there is a rule about the

way in which the wind changes which is very important. It is well known to every sailor, and is contained in the following couplet:

"When the wind shifts against the sun,
Trust it not, for back it will run."

The wind usually shifts *with the sun*, *i.e.*, from left to right, in the NORTHERN HEMISPHERE. A change in this direction is called *veering*.

Thus an East wind shifts to West through Southeast; South, Southwest; and a West wind shifts to East through Northwest, North, and Northeast.

If the wind shifts the opposite way, viz., from West to Southwest, South, and Southeast, the change is called *backing*, and it seldom occurs unless when the weather is unsettled.

However, slight changes of wind do not follow this rule exactly; for instance, the wind often shifts from southwest to south and back again.

In the SOUTHERN HEMISPHERE the motion *with the sun* is, of course, from right to left, and, therefore, the above rules will necessarily be reversed.

Admiral FITZROY proposed the following words for barometer scales:—

RISE.	FALL.
For North N.W.—N.—E. Dry or less Wind. — Except Wet from North.	For South S.E.—S.—W. Wet or more Wind. — Except Wet from North.

Buys-Ballot's Law.

The law connecting barometric pressure with the direction of wind which has been proposed by Professor BUYS-BALLOT, may be stated thus: If *there be a difference* between the barometric readings at

any two stations, the wind will blow at *right angles* to the line joining these two places, and the observer, standing with his back to the wind, will have the place where the reading is lowest on the left hand side in the NORTHERN HEMISPHERE, but on the right hand side in the SOUTHERN HEMISPHERE.

No reading from a barometer which is not hanging truly vertically should ever be recorded.

THE ANEROID.

In the aneroid, atmospheric pressure is measured by its effect in altering the shape of a small, hermetically-sealed metallic box, from which almost all the air has been withdrawn, and which is kept from collapsing by a spring.

When atmospheric pressure rises above the amount which was recorded when the instrument was made, the top is forced inwards, and *vice versa*, when pressure falls below that amount, the top is forced outwards by the spring.

These motions are transferred by a system of levers and springs to a hand, which moves on a dial like that of a wheel barometer. This instrument is very sensitive, showing minute changes that are concealed by the pumping of the quicksilver, even in the best constructed marine barometer, when the motion of the ship is violent. The aneroid can be registered with great facility, and, being portable, may be watched constantly when the marine barometer may not be accessible; nevertheless it should, when opportunity offers, be compared with a good mercurial barometer.

Range of the Barometer.—The average range of the barometer in the higher latitudes (60°–50°) is about 1.5 inches, but on extraordinary occasions, ranges of 2.75 and 3 inches have been recorded.

In the intertropical regions the range varies from 0.4 to 0.2 inches, and in the neighborhood of the equator it seldom exceeds 0.15 inches, this small change being due in great part to a regular diurnal variation. The average movement of the barometer within the tropics being thus confined within small limits, any interruption to the law may be deemed a warning of the approach of bad weather.

The fall of the barometer in hurricanes ranges from 1.0 to 2.0, and even 2.5 inches; the rapidity of the fall and the depression of *the mercury increases* as the centre of the storm approaches.

North Atlantic Ocean.

Mean Barometric Pressure Reduced to 32° Fahrenheit.

	Latitude.	Jan. In.	Feb. In.	March. In.	April. In.	May. In.	June. In.
For Eastern half or to 40th Meridian.	50° to 45°	30.15	30.12	29.90	29.96	29.94	30.00
	45° to 40°	30.16	30.11	30.10	30.01	30.02	30.05
	40° to 35°	30.18	30.07	30.12	30.06	30.07	30.20
	35° to 30°	30.22	30.14	30.10	30.16	30.12	30.20
	30° to 25°	30.17	30.23	30.13	30.17	30.22	30.23
	25° to 20°	30.10	30.11	30.10	30.10	30.14	30.16
	20° to 15°	30.01	30.06	30.04	30.00	30.06	30.03
	15° to 10°	29.95	29.97	29.96	29.97	29.99	29.96
	10° to 5°	29.90	29.94	29.91	29.92	29.94	29.94
	5° to 0°	29.88	29.91	29.89	29.90	29.92	29.93

	Latitude.	July. In.	August. In.	Sept. In.	Oct. In.	Nov. In.	Dec. In.
For Eastern half or to 40th Meridian.	50° to 45°	30.08	30.08	30.00	29.93	30.07	30.06
	45° to 40°	33.17	30.10	30.04	30.01	29.98	30.03
	40° to 35°	30.19	30.16	30.11	30.09	30.02	30.06
	35° to 30°	30.24	30.19	30.15	30.18	30.03	30.18
	30° to 25°	30.19	30.16	30.10	30.14	30.06	30 18
	25° to 20°	30.09	30.07	30.32	30.07	30.01	30.06
	20° to 15°	30.00	30.00	29.99	29.99	29.98	30.01
	15° to 10°	29.97	29.93	29.93	29.95	29.96	29 96
	10° to 5°	29.98	29.97	29.95	29.93	29.94	29.91
	5° to 0°	29.98	29.97	29.98	29.95	29.92	29.91

In the NORTHERN HEMISPHERE, the effect of the veering of the wind on the barometer is according to the following law:

With East, S.E., South winds, barometer falls.
" S.W. " " ceases to fall, begins to rise.
" West, N.W., North " " rises.
" N.E. " " ceases to rise, begins to fall.

South Atlantic Ocean.

Mean Barometric Pressure Reduced to 32° Fahrenheit.

Latitude.	Jan. In.	Feb. In.	March. In.	April. In.	May. In	June. In.
0° to 5°	29.89	29.91	29.90	29.92	29.94	29.94
5° to 10°	29.95	29.94	29.94	29.94	30.04	30.05
10° to 15°	29.97	29.98	29.96	29.99	30.04	30.05
15° to 20°	30.02	30.01	30.01	30.03	30.09	30.09
20° to 25°	30.06	30.05	30.07	30.05	30.06	30.14
25° to 30°	30.07	30.05	30.06	30.03	30.14	30.09
30° to 35°	30.05	30.05	30.04	30.03	30.10	30.04
35° to 40°	29.98	30.04	30.02	29.98	29.90	29.90
40° to 45°	29.92	29.95	29.99	29.95	29.98	29.89
45° to 50°	29.71	29.78	29.77	29.76	29.72	29.65
50° to 55°	29.41	29.44	29.49	29.44	29.41	29 48
55° to 60°	29.25	29.23	29.25	29.20	29.26	29.28

Latitude.	July. In.	August. In.	Sept. In.	Oct. In.	Nov. In.	Dec. In.
0° to 5°	29.99	30.00	30.01	29.96	29.94	29.93
5° to 10°	30.02	30.03	30.03	30.02	29.99	29.96
10° to 15°	30.05	30.06	30.09	30.07	30.04	30.00
15° to 20°	30.09	30.13	30.11	30.10	30.05	30.05
20° to 25°	30.11	30.16	30.17	30.18	30.08	30.08
25° to 30°	30.13	30.18	30.13	30.16	30.08	30.08
30° to 35°	30 12	30.10	30.10	30.08	30.09	30.00
35° to 40°	30 04	29.94	29.94	30.05	30.05	29.97
40° to 45°	29.95	29.93	29.96	30.02	29.94	29.95
45° to 50°	29.82	29.83	29.87	29.77	29.70	29.67
50° to 55°	29.53	29.56	29.57	29.48	29.81	29.48
55° to 60°	29.25	29.28	29.29	29.10	29.11	29.21

In the SOUTHERN HEMISPHERE, the effect of the veering of the wind on the barometer is according to the following law:

With East, N.E., North winds, barometer falls.				
"	N.W.	"	"	ceases to fall, begins to rise.
"	West, S.W.	"	"	rises.
"	S.E.	"	"	ceases to rise, begins to fall.

.bles of mean barometric pressure in the North and South Oceans, being for the temperature of 32° Fahrenheit, must :ted by the use of the following table :

Temperature of air.	Correction.
35°	+0.018
40°	+0.031
50°	+0.058
60°	+0.085
70°	+0.111
80°	+0.138
90°	+0.164

:ample : In the Atlantic Ocean on the Equator, with the ·ic table showing 29.90 and the temperature 80° Fahrenheit, ;ator's barometer would be 30.038.

THE THERMOMETER.

barometer shows weight and pressure of the air, so the ıeter shows heat and cold, or temperature.

:sult of many observations show that in the NORTHERN IERE :—The thermometer rises with E., S E., and S. winds; .W. wind it ceases to rise and begins to fall; it falls with ., and S. winds; and with a N.E. wind it ceases to fall and ı.ise.

the SOUTHERN HEMISPHERE:—The thermometer rises with , and N. winds; with a N.W. wind it ceases to rise and be- :all; it falls with W., S.W., and S. winds; and with a S.E. :eases to fall and begins to rise.

s the use of the thermometer, in conjunction with the bar- in foretelling the changes of weather, the seaman, by its aid, ıuently derive information when passing from one ocean cur- nother; it also may give warning of the vicinity of ice.

ıheit's thermometer is generally used in this country, and r's and the Centigrade abroad.

are disadvantages in the scales of Réaumur and Centigrade, ıgth *of each degree is much* greater than in Fahrenheit's, and

not so easily nor accurately read when the mercury is between the lines of division; and the temperatures requiring to be registered being often below the freezing of water, are always obliged to be expressed by negative signs.

The different scales are easily convertible by the following rules:

CENTIGRADE TO FAHRENHEIT. Multiply by 9, divide by 5, and add 32.

Cent.

$\frac{9}{5}$ C. $+32° =$ F., or $100° \times 9 = 900 \div 5 = 180 + 32 = 212°$ Fahrenheit.

RÉAUMUR TO FAHRENHEIT. Multiply by 9, divide by 4, and add 32.

Réau.

$\frac{9}{4}$ R. $+32° =$ F., or $80° \times 9 = 720 \div 4 = 180 + 32 = 212°$ Fahrenheit.

FAHRENHEIT TO CENTIGRADE. Subtract 32, multiply by 5, and divide by 9.

Fahr.

(F. $-32°$.) $\frac{5}{9} =$ C., or $212° - 32 = 180 \times 5 = 900 \div 9 = 100°$ Centigrade.

FAHRENHEIT TO RÉAUMUR. Subtract 32, multiply by 4, and divide by 9.

Fahr.

(F. $-32°$.) $\frac{4}{9} =$ R., or $212° - 32 = 180 \times 4 = 720 \div 9 = 80°$ Réaumur.

CENTIGRADE TO RÉAUMUR. Multiply by 4, and divide by 5.

Cent.

$\frac{4}{5}$ C. $=$ R., or $100° \times 4 = 400 \div 5 = 80°$ Réaumur.

RÉAUMUR TO CENTIGRADE. Multiply by 5 and divide by 4.

Réau.

$\frac{5}{4}$ R. $=$ C., or $80° \times 5 = 400 \div 4 = 100°$ Centigrade.

Comparison of the Fahrenheit, Centigrade, and Réaumur Thermometers.

Fahrenheit.	Centigrade.	Réaumur.	Fahrenheit.	Centigrade.	Réaumur.	Fahrenheit.	Centigrade.	Réaumur.
Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.
1	−17.2	−13.8	35	1.7	1.3	69	20.6	16.4
2	16.7	13.3	36	2.2	1.8	70	21.1	16.9
3	16.1	12.9	37	2.8	2.2	71	21.7	17.3
4	15.6	12.4	38	3.3	2.7	72	22.2	17.8
5	15.0	12.0	39	3.9	3.1	73	22.8	18.2
6	14.4	11.6	40	4.4	3.6	74	23.3	18.7
7	13.9	11.1	41	+ 5.0	+ 4.0	75	23.9	19.1
8	13.3	10.7	42	5.6	4.4	76	24.4	19.6
9	12.8	10.2	43	6.1	4.9	77	25.0	20.0
10	12.2	9.8	44	6.7	5.3	78	25.6	20.4
11	−11.7	9.3	45	7.2	5.8	79	26.1	20.9
12	11.1	8.9	46	7.8	6.2	80	26.7	21.3
13	10.6	8.4	47	8.3	6.7	81	27.2	21.8
14	10.0	8.0	48	8.9	7.1	82	27.8	22.2
15	9.4	7.6	49	9.4	7.6	83	28.3	22.7
16	8.9	7.1	50	+10.0	+ 8.0	84	28.9	23.1
17	8.3	6.7	51	10.6	8.4	85	29.4	23.6
18	7.8	6.2	52	11.1	8.9	86	30.0	24.0
19	7.2	5.8	53	11.7	9.3	87	30.6	24.4
20	6.7	5.3	54	12.2	9.8	88	31.1	24.9
21	− 6.1	4.9	55	12.8	10.2	89	31.7	25.3
22	5.6	4.4	56	13.3	10.7	90	32.2	25.8
23	5.0	4.0	57	13.9	11.1	91	32.8	26.2
24	4.4	3.6	58	14.4	11.6	92	33.8	26.7
25	3.9	3.1	59	15.0	12.0	93	33.9	27.1
26	3.3	2.7	60	15.6	12.4	94	34.4	27.6
27	2.8	2.2	61	16.1	12.9	95	35.0	28.0
28	2.2	1.8	62	16.7	13.3	96	35.6	28.4
29	1.7	1.3	63	17.2	13.8	97	36.1	28.9
30	1.1	0.9	64	17.8	14.2	98	36.7	29.3
31	− 0.6	− 0.4	65	18.3	14.7	99	37.2	29.8
32	0.0	0.0	66	18.9	15.1	100	37.8	30.2
33	+ 0.6	+ 0.4	67	19.4	15.6			
34	1.1	0.9	68	20.0	16.0			

Maxima and Minima Thermometers.—The object of these is to point out, in the absence of the observer, the extremes of heat and cold. They are self-registering and very useful instruments. The one generally preferred is Rutherford's, on account of its great simplicity and easy adjustment for each fresh observation. The two thermometers, that is the one for registering the *maxima*, and that for registering the *minima*, should be on separate mountings, which may be either of wood or metal.

Barometric or Boiling Point Thermometers.—The object of these thermometers is to ascertain approximately the heights of places by the temperature at which water boils.

Their range is from 180° to 215° Fahrenheit, the latter being somewhat above the temperature at which water boils at the level of the sea under ordinary circumstances, and the former a temperature at which it would boil at an elevation of between 17,000 and 18,000 feet. The graduation should be divided into fifths or tenths of a degree. A small copper pot should also accompany the thermometers, into which they are to be adjusted.

Thermometers for Ascertaining the Temperature of Water at Great Depths.—The chief peculiarities of these thermometers consists in having their bulbs enveloped with some bad conductor of heat, so that the temperature acquired by the instrument may be in no danger of changing in raising it through strata of water of different temperatures. Tow, cotton, wool, linen. pounded charcoal, or tallow will answer the purpose, and the choice of these will depend upon circumstances.

Thermometer for Solar Radiation.—A maximum register thermometer, with its bulb uniformly blackened with lamp-black and varnish, may be used. To observe the solar radiation it should be set about an inch above the bare soil and screened from currents of air. It must of course be so placed as to receive the full influence of the sun's direct rays at those hours of the day when they are hottest.

Thermometer for Terrestrial Radiation.—This instrument consists of a parabolic metallic mirror, about six inches in diameter, in the focus of which is placed the bulb of a register spirit thermometer, whose graduated stem passes through sockets in the sides of the

mirror, where it is accurately adjusted by corks. To use the instrument, place it in an open space away from the vicinity of high buildings, trees, etc., and clear of the ground. In all cases its height above the ground, the nature of the soil, or other object over which it is placed, should be noted.

WINDS.

WINDS are named from the direction in which they blow, as *North winds*, *East winds*, etc., *Land* and *Sea breezes*, *Trade winds*, *Monsoons*, *Cyclones*, *Typhoons*, *Hurricanes*, *Tornadoes*, etc., are names used to designate particular classes of winds.

In the Mediterranean, various local names are applied to the winds, as follows:

North.—*Tramontana* and *Gli Secchi*, or dry winds, by the Italians.

N.E.—The *Gregale* of the Italians and Maltese; the *Bora* of the Adriatic.

East.—*Solano* and *Levanter* of the Straits; *Levante*, *Bentu de Sole*, and when light, *Chocolatero* by the Italians.

S.E.—*Scirocco*, the hot debilitating wind of South Italy and Africa; *Maledetto*, *Levante*, *Molezzo*, and in the Adriatic, when strong, *Furiante*.

South.—*Mezzo Giorno;* from S. to S.W. *Simoom*, *Shume* or *Siume*, on the African Coast.

S.W.—*Vandavales;* also *Lebeches*, and *Virazones*, by the Spanish. *Libeccio;* when gusty, *Labeschades;* and when very stormy, accompanied by lightning, rain, etc., it is called *Ouragans* by the Italians. *Labbetch*, in Algeria; and *Siffanto* in the Adriatic.

West.—It is called in the Straits of Gibraltar the *Liberator*. *Ponente* (strong) by the Italians.

N.W.—The *Mistral*, *Mistrasu*, the *Bize*, and *Grippe*, also the *Vent de cers* of France. *Maestro*, *Maestrale*, of the Italians; and when light it is called *Mamatete* by the Sicilians.

N.N.W.—*Provenzale* by the Italians of Livorno.

A Sea Breeze.—*Imbattu.*

A Land Breeze.— *Vento di Terra* or *Rampinu.*

Land Squalls.—*Raggiature* by the Italians.

Mountain Storms.—*Burrasche*, South Italy, and *Raffiche* in Corsica.

Golfada, a hard gale. *Bonaceia*, calms between land and sea breezes, in Italy.

The meeting of opposing winds is called *Contrastes* by the Spaniards.

Prevailing winds are those which blow a great portion of the time from one direction, such as the trade winds, etc. South and southwest winds prevail on the west coast of Africa throughout the year.

Periodical winds are those which blow from a certain direction at particular seasons in each year. Such are the monsoons. On the coast of Africa, from Cape Verde to Sierra Leone, southwest winds blow from June to September, and northwest winds from October to May; and on the east coast of Africa, northerly and southerly winds alternate in winter and summer. The *Levante* blows from about northeast in the Ægean Sea, from about 9 A.M. throughout the day.

The greater portion of the inter-trade region is occupied by *variable* winds, depending on circumstances of temperature, pressure, moisture, and magnetism for their force and direction.

As a rule, barometric changes of pressure are followed by changes in the wind; and these, in connection with changes in temperature, and in the hygrometric condition of the atmosphere, indicate to a certain extent the nature of the change in the wind.

When the wind in the NORTHERN HEMISPHERE shifts from left to right—*i.e.*, with the sun—it is said to *haul*, when in the opposite direction it is said to *back*. This is reversed in the SOUTHERN HEMISPHERE. As a rule, a rise in the barometer indicates dry winds; a fall, wet winds.

Beaufort's Scale.

Hourly velocity in miles.	Scale.	State.	Sail carried.
	0	Calm.	
1	1	Light airs	Steerage way.
2 to 3	2	Light breeze	Clean full—1 to 2 knots.
4 to 7	3	Gentle breeze	" 3 to 4 knots.
9 to 15	4	Moderate breeze	" 5 to 6 knots.
15 to 18	5	Fresh breeze	With royals.
19 to 22	6	Strong breeze	Topgallant sails over single reefs.
23 to 28	7	Moderate gale	Two reefs in topsail.
28 to 40	8	Fresh gale	Three reefs in topsail.
40 to 48	9	Strong gale	Close-reefed topsails and courses.
48 to 56	10	Whole gale	Close reefed topsails and reefed foresail.
57 to 80	11	Storm	Storm staysails.
80 to 100	12	Hurricane	Bare poles.

This scale of numbers is in universal use to denote the force and velocity of the wind.

Definitions of Certain Terms in Use.

With regard to the position of the ship, she is *close to the wind*, *on a wind*, *or by the wind*, when the yards are braced up and the wind comes from a quarter from four to six points on the bow. The wind is a *head wind*, a *leading wind*, a *free wind*, a *fair wind*, a *large wind*, or a *scant wind*, according as it blows toward the sails at different angles with the keel line. *In the wind's eye* means directly toward the wind. *Between wind and water*, near the water-line, that portion of the ship's side which, when she rolls, is covered and uncovered by the water.

When the wind goes toward the bow of a ship it is said to *haul*, when toward the stern, to *veer* or *draw aft*.

Wind in the teeth—Wind directly ahead.

Wind-gall—A luminous halo on the edge of a distant cloud, generally to windward, and the precursor of bad weather. Similar halos are seen to leeward.

Winds in the Indian Ocean.

Arabian Sea.	Bay of Bengal.	China Sea.
November to March, N.E. Moonson. Moderate and Fine.	November to March, N.E. Monsoon. Moderate and Fine.	October to April, N.E. Monsoon. Blows fresh in Nov., Dec., and Jan.
May to September, S.W. Monsoon. Blowing fiercely, with bad weather in June and July; moderating in August.	May to September, S.W. Monsoon. Blowing fresh, with bad weather in June and July; moderating in August.	May to September, S.W. Monsoon. Moderate, with rain, strongest in June, July and August.

Atlantic Ocean.

Average Limits of the Trade Winds.

Months.		Jan., Feb., March.	April, May, June.	July, Aug., Sept.	Oct., Nov., Dec.
N.E. Trade	Northern Boundary	25° N.	27° N.	23° N.	24° N.
	Southern Boundary	2° N.	4° N.	11° N.	6° N.
Breadth of Variable Belt		120 miles.	180 miles.	500 miles.	200 miles.
S.E. Trade	Northern Boundary	The Equator	1° N.	3° N.	3° N.
	Southern Boundary	A line drawn from the Cape of Good Hope to the Isles of Trinidad and Martin Vaz.			
Rainy Seasons.		Guayana & North Brazil — Africa (south of the Equator).	Guayana, Brazil, and Africa (north of the Equator), in May and June; Caribbean Sea in June.	West Indies and Africa (north of the Equator). — Brazil in July and Aug.	Guayana in Dec., Africa (south of the Equator) in Nov. & Dec.

Pacific Ocean.

Average Limits of the Trade Winds Eastward of the Meridian of 160° West.

Months.		Jan., Feb., March.	April, May, June.	July, Aug., Sept.	Oct., Nov., Dec.
N.E. Trade	Northern Boundary	28° N.	29° N.	31° N.	28° N.
	Southern Boundary	8° N.	10° N.	12° N.	11° N.
Breadth of Variable Belt		300 miles.	450 miles.	180 miles.	300 miles.
S.E. Trade	Northern Boundary	4° N.	4° N.	9° N.	6° N.
	Southern Boundary	A line drawn from Juan Fernandez through Easter Isd. and the Marquesas.	A line drawn from St. Felix Isd. toward Tahiti, as far as the Mer. of 135° W.	A line drawn from St. Felix Island to Tahiti.	A line drawn from Valparaiso toward Tahiti, as far as the Mer. of 135° W.
RAINY SEASONS.		Sandwich Island and Coast of Ecuador. — South Pacific Isds.	Mexico and Central America in June.	Mexico and Central America.	Sandwich Isds. and Coast of Ecuador in December. — South Pacific Islands in Nov. & Dec.

East Coast of Africa and the Mozambique Channel.

December to March, **Northerly Winds.** April to November, **Southerly Winds.**

Between the Equator and the Parallel of 10° South.

November to March,

N.W. or Middle Monsoon. *A light wind, with squalls, rains, and frequent calms.*

April to September,

S.E. Trade.

Between the Parallels of 10° and 25° or 30° South.

Constant S.E. Trade.

Squalls.

Generally squalls are preceded, accompanied, or followed by clouds; but the dangerous "white squall" (of the West Indies and other regions) is indicated only by a rushing sound, and by white wave-crests.

A squall-cloud that can be seen through or under is not likely to be accompanied by so much wind as a dark continued cloud extending beyond the horizon.

The rise of a cloud, its more or less disturbed look—that is, whether it is much agitated and continually changing form, with scud flying about; or whether the mass of cloud is shapeless or quiet, though floating across the sky—foretells more or less wind as the case may be.

Though trite and simple, there is so much truth in some of the saws about wind and weather, that they are given below.

Adverting to the barometer:—

When rise begins after low,
Squalls expect and clear blow.

or:—

First rise, after low,
Indicates a stronger blow.

Also:—

Long foretold, long last,
Short notice, soon past.

Referring to squalls:

When the rain's before the wind,
Halliards, sheets, and braces mind.

And:

When the wind's before the rain
Soon you may make sail again.

Generally speaking:

When the glass falls low,
Prepare for a blow;
When it rises high.
Let all your kites fly.

Hurricanes, Cyclones, Typhoons.

These storms are progressive revolving gales of great violence, and may be generally described as immense whirlwinds, turning round and rolling forwards at the same time.

Velocity of Travel.—The rate or velocity of translation of revolving storms varies in different localities; in storms passing over the same locality; and even in the same storm during different stages of its existence. The average rate of the progressive movement of the centre of the West Indian hurricanes is about three hundred miles a day; of those in the Bay of Bengal and China Sea, two hundred miles a day; while the cyclones of the Indian Ocean vary from fifty to two hundred miles in the twenty-four hours.

Dimensions.—The storms in the North Atlantic are said to commence with a small diameter, and then to increase to six hundred or one thousand miles after passing from the tropical regions. In the South Indian Ocean the range is from one hundred to six hundred miles, and in the China Sea from eighty to four hundred miles.

The seasons in which these storms prevail, are as follows:

Hurricanes.—West Indies and American Coast; Coasts of Mexico and Lower California in North Pacific Ocean; July to October, and occasionally November. In South Pacific Ocean, between Australian Coast and Low Archipelago, December to March.

Cyclones.—Malabar Coast and Bay of Bengal, April and May, and October to December. South Indian Ocean, December to April.

Typhoons.—China Sea, July to November. Coasts of Japan, August, September, October.

The peculiar characteristic of the revolving action of these storms is, that in each hemisphere of the world the gyration invariably takes place in one direction, and that direction contrary to the apparent course of the sun; so that in north latitudes these storms revolve from right to left, and in south latitudes from left to right. The knowledge of this law is the more especially important, as it not only supplies the seaman with direct means of distinguishing them from common gales, but it reveals to him the actual position of the centre or vortex with respect to the place of his vessel, and therefore points out the way to escape from them.

Law of Storms.—The theory of the motions of the winds within the storm-area, and the progressive movement of the storm, discovered by Redfield, verified by Reid, and confirmed by actual observations at sea, is generally known as the Law of Storms, and is based on the supposition that the air-currents within the limits of the storm disk move in nearly concentric circles round a centre of low pressure, from right to left, or against the hands of a watch (face up), in the NORTHERN HEMISPHERE, and from left to right, or with the hands of a watch, in the SOUTHERN HEMISPHERE; so that, when facing the wind, the centre lies on the right hand in the NORTHERN, and on the left hand in the SOUTHERN HEMISPHERE.

The nearest approach to the true average motion of the wind is probably a spiral curve, any small portion of which may, for all practical purposes, be considered the arc of a circle, whose centre coincides with the storm centre.

Storm Indications.—The indications of the approach of a cyclone do not differ materially from those of an ordinary gale; but a few, such as a hard steel-gray sky, or a sky having a greenish tint; a blood-red or bright yellow sunset; a heavy swell, unaccounted for in any other way; and a thick, lurid appearance of the sky, may be regarded, in connection with a general threatening appearance of the weather, and a restless state of the barometer, as significant signs of a more than ordinary gale, and ought not to be disregarded.

Barometer.—The barometer as an instrument of warning, and also as an approximate measure of the distance from the centre of a cyclone, is of vital importance to the seaman.

First.—The barometer generally indicates the approach of a storm by a restless, oscillating motion of the mercury, caused by a disturbed condition of the atmosphere in the vicinity of the storm. These oscillations may vary from a just perceptible motion to 0.02 inch.

Second.—The barometer often rises suddenly just in front of a storm by reason of the air banking up; therefore, if there are other storm indications, the rise in the barometer, if any occurs, is no guarantee that it will not come, but rather a sign that the storm will *be severe.*

Third.—A very rapid fall of the barometer, after fairly entering the storm-disk, may be taken as evidence of a violent storm of small diameter, and a gradual fall would indicate the contrary.

Fourth.—In the case of a vessel caught in a cyclone near the land, the knowledge of her distance from the centre may be all-important, even if it cannot be determined nearer than fifty miles, and to aid navigators in determining the distance from the centre, the following table from Piddington's Hornbook is given :

Average fall of barometer per hour.	Distance in miles from centre.
From 0.02 to 0.06 inch.	From 250 to 150
" 0.06 " 0.08 "	" 150 " 100
" 0.08 " 0.12 "	" 100 " 80
" 0.12 " 0.15 "	" 80 " 50

When the navigator has reason to suspect that a cyclone is not far distant, his first care is to devise a plan for avoiding it, and if he knows positively the direction of its course, this may often be accomplished.

An inspection of a cyclone-chart, such as is usually at hand, will give an approximate idea of the storm's movement, as the cyclone-tracks generally lie in the same direction, but it does not follow as a matter of fact that every cyclone travels over the beaten track, and hence there is no certainty that the approaching storm will do so.

By a knowledge of the tracks in the locality, the navigator may, however, try to avoid it ; but if, after all his efforts, he is still caught in the storm, he must at once determine his position in the storm-disk, and the course of the storm.

Rules.

Heave to, so as to remain as nearly as possible stationary, in order to observe the wind during the first depression of the barometer, and to decide from it the course for escape.

Right semicircle : Wind *changes to* the right, N., E., S., and W., heave to *on starboard tack.*

Left semicircle: Wind changes to the left, N., W., S., and E., heave to on *port tack*.

This may be reduced to six words, by associating the direction of the change of the wind with the semicircle of the storm and the tack on which to heave to; hence, we have for the right semicircle: *Right, right—starboard*, and for the left semicircle: *Left, left—port.*

This will place the ship in a safe position, north or south of the equator, until the course of the storm is determined.

The right semicircle is that portion of the storm-disk situated on the right of the axis of the storm-track, looking in the direction of its course; and the left semicircle the portion of the storm-disk lying on the left of that line.

Rotation of Wind.—NORTHERN HEMISPHERE: From *Right to Left;* or, in nautical language, against the sun.

SOUTHERN HEMISPHERE: From *Left to Right;* or with the sun.

Bearing of Centre.—NORTHERN HEMISPHERE: Eight points (90°) to the *right* of the wind-point, looking in the wind's eye.

SOUTHERN HEMISPHERE: Eight points (90°) to the left of the wind point, looking in the wind's eye.

Two bearings of the centre, with an interval of two to three hours between, will usually be sufficient to determine the course of the storm, provided an accurate account of the ship's way has been kept; but with slow-moving storms a longer interval may be necessary.

There are only two points in the disk of a cyclone where a vessel hove to will not experience a change of wind: one is in front of the centre on the line of its axis, and the other is in rear of the centre on the same line; for these two cases the barometer must be the guide—in front of the centre it falls, and in rear of the centre it rises.

To Run Out of the Storm in the Northern Hemisphere.

RIGHT SEMICIRCLE.—Haul by the wind on *starboard tack*, and carry sail as long as possible. If obliged to heave to, do so on *starboard tack*.

LEFT SEMICIRCLE.—Bring the wind on *starboard quarter.* Note the direction of the ship's head, and *steer that course.* If obliged to heave to, do so on *port tack.*

ON THE STORM-TRACK IN FRONT OF CENTRE: square away and *run before it.* Note the course and keep it, and trim the yards as the wind draws on the starboard quarter. If obliged to heave to, do so on *port tack.*

ON THE STORM-TRACK IN REAR OF CENTRE: *run out* with wind on *starboard quarter*, or heave to on starboard tack.

To Run Out of the Storm in the Southern Hemisphere.

RIGHT SEMICIRCLE.—Bring wind on *port quarter.* Note the course and keep it. If obliged to heave to, do so on *starboard tack.*

LEFT SEMICIRCLE.—Haul by the wind on *port tack.* Carry sail as long as possible, and if obliged to heave to, do so on *port tack.*

ON THE STORM-TRACK IN FRONT OF CENTRE; *run before it.* Note the course and keep it, and trim the yards as the wind hauls on the port quarter. If obliged to heave to, do so on *starboard tack.*

ON THE STORM-TRACK IN REAR OF CENTRE: *run out* with the wind on the *port quarter*, or heave to on *port tack.*

A rise of the barometer, and a gradual diminution of the force of wind will result from the above manœuvres; and the ship should invariably be kept on her course until it is made evident, by the improvement of the weather, that she is out of danger.

In all cases where sail cannot be carried, or land interferes, the ship must be hove to on the *starboard tack* in the *right* semicircle, and on the *port tack* in the *left* semicircle.

If after following out the above rules, the barometer continues to fall, and the weather becomes worse, it is evidence that the indraft is very great, and in extreme cases, where it is found impracticable to avoid the centre by sailing, the vessel should be hove to on the proper tack and made snug for a *heavy blow*, until the centre has passed.

Dove's Tables.

Indicating how a Ship should be Handled in a Revolving Storm in the Northern Hemisphere.

	Direction of wind at beginning of storm.	Bearing of centre from ship.	If the shift of wind be from	Then steer		If the shift of wind be from	Then
1	N.W.	N.E.	N.W. toward W.	S.E.		N.W. toward N.	
2	N.W. by N.	N.E. by E.	N.W. by N. " W.	S.E. by S.		N.W. by N. " N.	
3	N.N.W.	E.N.E.	N.N.W. " W.	S.S.E.		N.N.W. " N.	
4	N. by W.	E. by N.	N. by W. " W.	S. by E.		N. by W. " N.	
5	N.	E.	N. " W.	S.		N. " E.	
6	N. by E.	E. by S.	N. by E. " N.	S. by W.		N. by E. " E.	
7	N.N.E.	E.S.E.	N.N.E. " N.	S.S.W.		N.N.E. " E.	
8	N.E. by N.	S.E. by E.	N.E. by N. " N.	S.W. by S.		N.E. by N. " E.	
9	N.E.	S.E.	N.E. " N.	S.W.		N.E. " E.	
10	N.E. by E.	S.E. by S.	N.E. by E. " N.	S.W. by W.		N.E. by E. " E.	
11	E.N.E.	S.S.E.	E.N.E. " N.	W.S.W.		E.N.E. " E.	
12	E. by N.	S. by E.	E. by N. " N.	W. by S.		E. by N. " E.	
13	E.	S.	E. " N.	W.	Or else heave the ship to on the port tack.	E. " S.	Ship to be hove to on the starboard tack.
14	E. by S.	S. by W.	E. by S. " E.	W. by N.		E. by S. " S.	
15	E.S.E.	S.S.W.	E.S.E. " E.	W.N.W.		E.S.E. " S.	
16	S.E. by E.	S.W. by S.	S.E. by E. " E.	N.W. by W.		S.E. by E. " S.	
17	S.E.	S.W.	S.E. " E.	N.W.		S.E. " S.	
18	S.E. by S.	S.W. by W.	S.E. by S. " E.	N.W. by N.		S.E. by S. " S.	
19	S.S.E.	W.S.W.	S.S.E. " E.	N.N.W.		S.S.E. " S.	
20	S. by E.	W. by S.	S. by E. " E.	N. by W.		S. by E. " S.	
21	S.	W.	S. " E.	N.		S. " W.	
22	S. by W.	W. by N.	S. by W. " S.	N. by E.		S. by W. " W.	
23	S.S.W.	W.N.W.	S.S.W. " S.	N.N.E.		S.S.W. " W.	
24	S.W. by S.	N.W. by W.	S.W. by S " S.	N.E. by N.		S.W. by S. " W.	
25	S.W.	N.W.	S.W. " S.	N.E.		S.W. " W.	

In this table the shift of wind is supposed to be observed from a stationary point; as from a vessel hove to.

Dove's Tables.

Indicating how a Ship should be Handled in a Revolving Storm in the Southern Hemisphere.

	Direction of wind at beginning of storm.	Bearing of centre from ship.	If the shift of wind be from	Then steer		If the shift of wind be from.	Then
1	S.	E.	S. toward W.	N.	Or else heave the ship to on starboard tack.	S. toward E.	Ship to be hove to on the port tack.
2	S. by E.	E. by N.	S. by E. " S.	N. by W.		S. by E. " E.	
3	S.S.E.	E.N.E.	S.S.E. " S.	N.N.W.		S.S.E. " E.	
4	S.E. by S.	N.E. by E.	S.E. by S. " S.	N.W. by N.		S.E. by S. " E.	
5	S.E.	N.E.	S.E. " S.	N.W.		S.E. " E.	
6	S.E. by E.	N.E. by N.	S.E. by E. " S.	N.W. by W.		S.E. by E. " E.	
7	E.S.E.	N.N.E.	E.S.E. " S.	W.N.W.		E.S.E. " E.	
8	E. by S.	N. by E.	E. by S. " S.	W. by N.		E. by S. " E.	
9	E.	N.	E. " S.	W.		E. " N.	
10	E. by. N.	N. by W.	E. by N. " E.	W. by S.		E. by N. " N.	
11	E.N.E.	N.N.W.	E.N.E. " E.	W.S.W.		E.N.E. " N.	
12	N.E. by E.	N.W. by N.	N.E. by E. " E.	S.W. by W.		N.E. by E. " N.	
13	N.E.	N.W.	N.E. " E.	S.W.		N.E. " N.	
14	N.E. by N.	N.W. by W.	N.E. by N. " E.	S.W. by S.		N.E. by N. " N.	
15	N.N.E.	W.N.W	N.N.E. " E.	S.S.W.		N.N.E. " N.	
16	N. by E.	W. by N.	N. by E. " E.	S. by W.		N. by E. " N.	
17	N.	W.	N. " E.	S.		N. " W.	
18	N. by W.	W. by S.	N. by W. " N.	S. by E.		N. by W. " W.	
19	N.N.W.	W.S.W.	N.N.W. " N.	S.S.E.		N.N.W. " W.	
20	N.W. by N.	S.W. by W.	N.W. by N. " N.	S.E. by S.		N.W. by N. " W.	
21	N.W.	S.W.	N.W. " N.	S.E.		N.W. " W.	

In this table the shift of wind is supposed to be observed from a stationary point; as from a vessel hove to.

The following is a summary of some results of an investigation, by Prof. Elias Loomis, of storms in the Atlantic:

"The prevalent direction of the wind in the neighborhood of the West India Islands is from the northeast. Occasionally a strong wind sets in from a southerly quarter. The interference of these winds gives rise to a gyration, and sometimes rainfall is the result. When rain commences, the latent heat which is liberated causes the wind to flow in from *all quarters*, by which the rainfall is in-

creased; and since the winds are deflected by the rotation of the earth, an area of low pressure is produced, and the force of the winds is maintained as long as the rainfall continues. The effect of this strong wind from the south is to transport the low centre in a northerly direction and by the combined action of this south wind and the normal wind from the northeast, the centre of low pressure is usually carried in a direction between the north and west.

The following summary presents some of the results derived from this investigation.

First.—The lowest latitude in which a cyclone has been found near the West India Islands is ten degrees, and the lowest latitude in the neighborhood of Southern Asia is six degrees. Violent squalls and fresh gales of wind have, however, been encountered directly under the equator.

Second.—The ordinary course of tropical hurricanes is towards the west northwest. In a few cases they seemed to have advanced towards a point a little south of west, and in a few cases their course has been almost exactly towards the north.

Third.—Tropical hurricanes are invariably accompanied by a violent fall of rain. This rainfall is never less than five inches in twenty-four hours for a portion of the track, and frequently it exceeds ten inches in twenty-four hours.

Fourth.—Tropical storms are generally preceded by a northerly wind, and after the passage of the low centre the wind generally veers to the southeast at stations near the centres; and the southerly wind which follows the low centre is generally stronger than the northerly wind which preceded it. This fact appears to suggest the explanation of the origin of the cyclone and the direction of its progressive movement."

ICE.

In some frequented portions of the ocean, ice appears every year, in the various forms of *field ice*, *floes*, and massive ice islands, drifted from the Arctic regions by the action of the polar currents. A strict attention to the lookout night and day is required when within the ice limits, and a careful attention to the temperature of the air and sea can hardly be overrated.

The indications of the thermometer cannot, however, be taken as an infallible guide; the vicinity of large bodies of packed ice, or numerous icebergs, will sensibly affect the temperature of both air and water to a considerable distance; but the chilling influence of a solitary iceberg may not lower the temperature to windward, or on either side to any distance; nor will the general temperature of the sea be altered, except in the track in which the berg is drifting. Icebergs should always be passed to one side to avoid the detached fragments, lying low in the water, which are often found astream of the berg in masses sufficiently great to stave in the bows of the strongest ship.

The approach of an iceberg is often indicated by a peculiar light, known as "*ice blink*," which is sometimes seen at a distance, even on a dark night. On coming close to the iceberg, this light has the effect of a white cloud settling over the rigging. The proximity of icebergs is also known by the noise of the waves breaking over them; this is sometimes heard at a great distance, and resembles the noise made by breakers on the shore.

North Atlantic Ocean.—In the frequented parts of the North Atlantic, the limits of field-ice in March extend from Newfoundland to the southward as far as 42° N. latitude, and to the eastward of the meridian of 44° W.

During the second quarter of the year the limits of the field-ice region are slightly contracted, but icebergs may be met with within an area reaching out to the point where the meridian of 40° W. crosses the parallel of 40° N., and even to the east and south of this.

By August the field-ice has disappeared, but icebergs are still met with when westward of the meridian of 38° W., or northward of the parallel of 41° N. During the winter months the seas are comparatively clear.

This region of *field-ice* should as much as possible be avoided by vessels bound to or from the United States and Canada; by making the necessary detour, the length of the passage will be but little increased, and the risk to life and property will be considerably reduced.

North Pacific Ocean.—In the Northern Pacific there is no danger of meeting floating *ice below* 50° N., but it is not advisable to

10

pass that parallel in making passages between Japan, or China, and California.

Southern Hemisphere.—In the high southern routes, adopted of late years by navigators in the voyages to and from Australia and New Zealand, the greatest number of icebergs have been seen in the summer season, or in November, December, and January, and the smallest number in June and July. It has also been observed that more icebergs are seen in March. During February, the limit of the iceberg region in the South Atlantic extends as far north as 39° S., while in August they are rarely found to the northward of the forty-fifth parallel.

This change in the limits of the iceberg region is specially noticeable in that portion of the Atlantic Ocean to the westward of Cape Horn, a district that should be navigated with great caution with regard to ice.

Numerous icebergs have also been fallen in with southward of Cape Leeuwin during January and February, in about the parallel of 44° S., and between the meridians of 105° and 140° E.

In making passages between the Cape of Good Hope and Australia, the sailor is cautioned against adopting a high southern route. By crossing the Indian Ocean, between the parallels of 42° and 43° S., the danger of encountering icebergs will not only be avoided, but better weather will most probably be experienced. Similarly between Australia, or New Zealand, and Cape Horn, navigators are recommended to cross the Pacific Ocean on or near the parallel of 52° S. until reaching the neighborhood of Cape Horn.

The indications of the thermometer should not be neglected in these seas, as there is generally a diminution of temperature of the air and sea on approaching ice; this, however, must not be assumed as an infallible guide. Icebergs should, if possible, be passed to windward, to avoid the loose ice floating to leeward.

TIDES.

THE surface of the ocean rises and falls twice in a lunar day, about 24 h. 52 m. of mean time.

On the coast the tides appear as alternate elevations and depressions of the sea, and also as horizontal movements of the water, al-

ternately flowing and ebbing; and the word tide is commonly used to designate both phases of the phenomenon.

In hydrography the term *tide* signifies only the vertical movement of the water, and the words *rise* and *fall* are used with reference to the same motion. *Stand* is the term used to denote the interval of time at high or low water, during which no vertical motion is perceptible. The *range* of the tide is the height from low water to high water.

The horizontal movement of the water is known as the *tidal current*, and the terms *flood* and *ebb* are used to indicate the general direction of the current. *Slack* is the word used to designate the interval of time during which no horizontal motion is perceptible.

The tides do not always rise to the same height, but every fortnight, after the new and full moon, they become much higher than they were in the alternate weeks, or after the first and last quarters of the moon.

These high tides are called *Spring Tides*, and the low ones *Neap Tides*.

The close relation which the times of high water bear to the times of the moon's meridian passage, show that the moon's influence in raising the tides is much greater than that of the sun.

While the whole attraction of the sun upon the earth far exceeds that of the moon, yet, owing to the greater proximity of the latter, the *difference* between its attraction at the centre of the earth and at the nearest or most remote point of its surface (which difference produces the tides) is about two and a half times as great as the difference of the sun's attraction at the same points. Though each of these bodies may be supposed to cause two tidal waves, the tides must be regarded as the result of their combined action.

At the time of full and change of the moon, the combined effect produces the spring tides, and high water is then *higher* and low water *lower* than at mean tides. When the moon is in perigee, or nearest the earth, the rise and fall is sensibly increased.

When the moon is in quadrature, or 90° from the sun, the attraction of the two bodies upon the waters act in opposition, and the neap tides are produced.

Very small tides will take place about the time of the earth's perihilion passage, if the moon is in apogee and also in quadrature.

During the first and third quarters of the lunar month the solar

wave lies to the west of the lunar wave, and the combined tide wave will be to the westward of that, due to the moon alone; and this causes an acceleration of the time of high water commonly called *priming*. In the second and fourth quarters the sun's influence acts to retard the lunar wave, and causes what is known as *lagging* of the tides.

The interval of time which elapses from the time of the moon's transit over the meridian of a place to that of high water next following at the same meridian, is called the *luni-tidal interval.*

It is found in general that any particular tide is not due to the moon's transit immediately preceding, but to a transit which has occurred some time before, and which is said therefore to correspond to it. The interval between the transit of the moon, at which a tide originates, and the appearance of a tide itself, is called the *retard* or age of the tide.

The Diurnal Inequality is a regular change, considerable in amount, and almost universal in prevalence. This change depends principally upon the moon's being north or south of the equator; its maximum is consequent on, but not always simultaneous with, the moon's greatest declination, and the period of its vanishing corresponds in like manner with the moon's passing the equator.

If the declination of the moon is of the same name as the latitude of the place, the greater of the daily tides occurs next after the upper transit of the moon; but if the latitude and declination have contrary names, the higher tide of the day follows the lower culmination of the moon. The diurnal inequality sometimes affects the time of high water as much as two hours, that of low water about forty minutes; at the same time a variation of a foot may be observed in the height of high water, and of three feet in that of low water. Such effects are too great to be neglected, either in the prediction of tides or the reduction of soundings.

The directions of strong winds, as well as the varying pressure of the atmosphere, considerably affect both the times and the heights of high water.

Half-monthly Inequality.—The time of the moon's transit advances from 0 h. on the day of new moon to 12 h. at full moon. If we *observe the change* in the length of the luni-tidal intervals from *conjunction to opposition*, or the reverse, and the changes in the range

of the tide during the same period, it will appear that the variations depend upon the hours of the moon's transit, the same form of tide occurring at equal intervals from the times of conjunction and opposition.

This alteration in the tide during the semi-lunar month is called the half-monthly inequality.

Establishment of the Port.—It is of great importance to be able to find the time of high water for harbors and ports, and for this purpose a standard is fixed upon, indicated by a particular position of the moon and sun, from which the time of any tide may be deduced. This standard is the time of high water at full and change of the moon, at the given point, reckoned from apparent noon. It is called the establishment of the port. The mean of the values of the luni-tidal intervals on the days of full and new moon is called the *common establishment* of a port.

The *corrected establishment* is the mean of all the luni-tidal intervals in a lunar month.

If the actions of the sun and moon were uninterrupted by obstacles or forces of other kinds, the tides would be regular and their calculation certain. But from the unequal depth of the ocean and the barriers presented by continents which stand across the natural progress of the tides, their motion is interrupted, and the tide-wave, abandoned by the forces which orginated it, becomes subject to the mechanical action proper to waves in general.

Co-tidal lines are lines drawn upon a map connecting all those places at which high water occurs at the same instant of time. Numerals are usually placed over these lines to indicate the hours of Greenwich time, on the days of full and change, at which high water occurs of the different lines. An inspection of such lines will show that the great tide-wave originates in the Pacific, west of the South American coast. Thence, travelling northwest, it reaches the coast of Kamtschatka in about ten hours.

The same wave, traversing the shallow waters of the South Pacific, passes New Zealand in twelve hours; continues on to the Cape of Good Hope, turns into the Atlantic, and finally reaches the coast of the United States about forty hours after its formation. Another branch passes by Cape Horn and turns eastward into the Atlantic.

Tide and Half-Tide, Tide and Quarter-Tide.

The interval between high and low waters in the open sea, about six hours and twelve minutes, is designated a "tide."

In channels where a tidal stream is formed, when the stream continues to flow up for three hours after it is high water, it is said to make a "tide and half-tide;" if it continue to flow for about one hour and a half after high water, it is said to make a "tide and quarter-tide."

The tides which take place far up bays, sounds, and rivers, are *later* than the tides at the entrance of such inlets, but they are not more irregular; on the contrary, the tides in such situations are often remarkably regular.

The tide in its progress up inlets and rivers is often much magnified or modified by local circumstances. Sometimes it is magnified so that the wave which brings the tide at one period of its rise advances with an abrupt front of broken water. This is called a *bore* (as in the Severn and Amazon). Sometimes the tide is divided into two half-day tides in its progress up the river, as in the Forth in Scotland. In all cases, after a certain point, the tide dies away in ascending a river.

The velocity of the tide-wave appears to be determined mainly by the depth of water through which it is propagated. According to Airy's rule, "*The rate at which the tide travels is equal to the velocity acquired by a body falling through space from a height equal to half the depth of water.*"

The range depends mainly upon the variations in width, and upon the configuration of the coast.

The velocity of the tide-wave by the above rule is as follows:

Depth of Water.	Velocity per Hour.
10 feet.	12 miles.
60 "	30 "
100 "	39 "
250 "	61 "
1,000 "	122 "
5,000 "	273 "
20,000 "	547 "
50,000 "	865 "

The form of tide may be represented upon a diagram, by plotting with the hours of the day as abscissas, and the height of the tide as ordinates.

Tidal Streams.—Besides the acquaintance with the periods of high and low water, and the comparative heights of the day and night tides, it is necessary to observe the direction of the stream of flood and ebb, and the time at which it turns; but care must be had not to confound the time of the turn of the tidal stream with the time of high water. The turn of the tidal stream generally takes place at a different time from high water, except at the head of a bay or river. The stream of flood usually runs for some time, often for hours, after the time of high water. In the same way the stream of ebb runs for some time after low water.

The most violent tidal currents which occur in navigable channels on our coast are those of Hell Gate, New York, and those near the junction of Vineyard and Nantucket Sounds.

Very little is known of tidal currents on outside coasts, except in the immediate neighborhood of certain dangerous shoals. A knowledge of them would, however, be often a great advantage in the saving of time in the passages of coasters.

Coasters frequently lose their reckoning, in quiet and thick weather, by being swept out of their courses by these drifts. The coast currents in some places have a velocity of a third of a mile per hour in thirty fathoms water. The epochs of coast currents may be expected to differ widely from those of the local tide, especially on a shore where differences of tidal range appear from point to point.

As an aid to navigation, it is very desirable to observe and tabulate the currents "on soundings."

TIDES AND TIDAL CURRENTS OF THE UNITED STATES.

THE Atlantic tides are of the most ordinary type, ebbing and flowing twice in twenty-four hours, and having but moderate differences in height between the two successive high waters or low waters, one occurring before noon and the other after noon. The coast presents in its general outline three large bays: the southern from Cape Florida to Cape Hatteras; the Middle from Cape Hatteras to Nan-

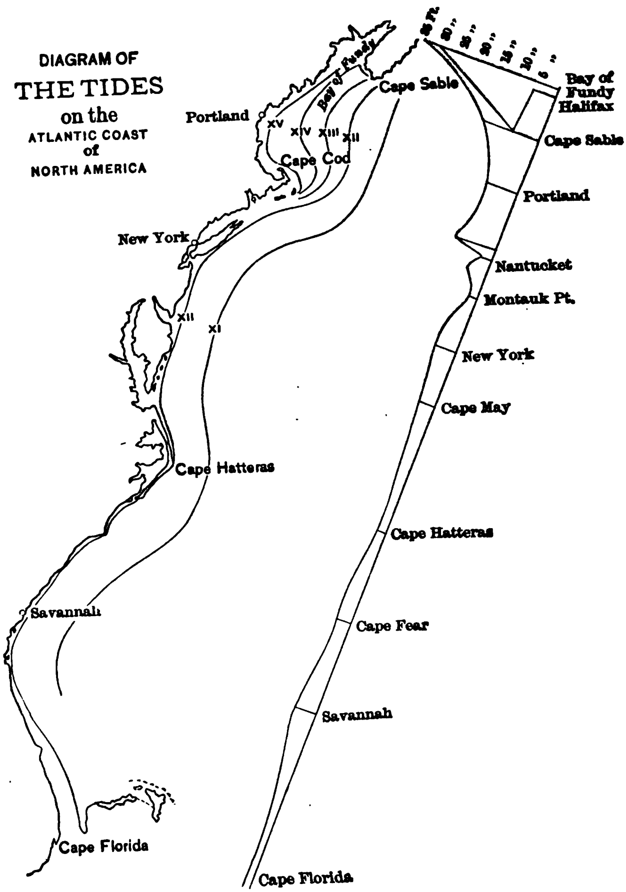


DIAGRAM OF
THE TIDES
on the
ATLANTIC COAST
of
NORTH AMERICA
Portland
Bay of Fundy
Cape Sable
XV
XIV
XIII
XII
Cape Cod
New York
XII
XI
Cape Hatteras
Savannah
Cape Florida
35 Ft.
30 "
25 "
20 "
15 "
10 "
5 "
Bay of Fundy Halifax
Cape Sable
Portland
Nantucket
Montauk Pt.
New York
Cape May
Cape Hatteras
Cape Fear
Savannah
Cape Florida

tucket; and the Eastern from Nantucket to Cape Sable, known as the Gulf of Maine. The tide-wave arrives at about the same time at the headlands, Cape Florida, Cape Hatteras, Nantucket, and Cape Sable, and at those points the height is inconsiderable compared with the rise at the head of the various bays. At Cape Florida the range is only one and one-half feet; at Hatteras, but two feet; while at the intermediate entrance to Savannah it reaches seven feet. Again, at the head of the middle bay, in New York harbor, it reaches five feet, while at Nantucket Island it is little over one foot. The recess of Massachusetts Bay is marked, the increase in height reaching ten feet at Boston. Rolling on along the coast of Maine, it steadily increases, and a striking effect of the convergence of shores is exhibited in the Bay of Fundy, which opens its bosom to receive the full wave. At St. Johns, the mean height of the tide is nineteen feet, and at Sackville thirty-six feet, swelling to the enormous height of sixty feet, and even more, at the highest spring tides.

Gulf of Maine.—Tidal currents at entrance. Along the line between Nantucket Shoals and Cape Sable Bank the ebb-current runs southwardly during the first four and a half hours after the *northing* or *southing* of the moon, and the flood-current northwardly from the sixth to the eleventh hour after the *northing* or *southing* of the moon. The time of turning on George's Bank corresponds nearly with the time of high or low water at Boston and Portland, but in the channel to the westward of the Bank it is later, and to the eastward earlier.

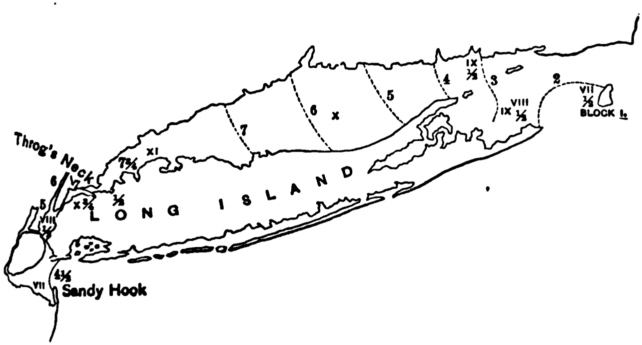
Rates and Direction of Currents for each Tidal Hour after Time of High Water at Boston.

Locality.	O. H.		I. H.		II. H.		III. H.	
	Rate Knots	Direction.	Rate Knots	Direction.	Rate Knots	Direction.	Rate Knots	Direction.
Great South Channel..	0.3	N. E. by N.	0.6	S.E.byE.½E.	1.0	S. ½ W.	1.3	S. by W.½W.
George's Shoal........	0.8	E.	1.5	S. E.	1.8	S. S. E.	1.9	S. by W.
Great Eastern Channel.	0.6	E. by S.	0.9	S. E.	1.3	S. S. E.	1.4	S. ¼ E.
Northern Channel	0.7	E. by N.	1.2	S. E.	1.3	S. E. ¼ S.	1.2	S.E.by S. ½S.
	IV. H.		V. H.		VI. H.		VII. H.	
Great South Channel..	1.2	S. by W.¼W.	0.9	S.by W.¼W.	0.3	S. W.¼S.	0.5	N. W. by W.
George's Shoal........	1.6	S. W.	1.2	S. W.	0.8	W. by S.	1.4	N. W. by W.
Great Eastern Channel.	1.3	S. W.	1.0	S. W.	0.3	W. S. W.	1.0	N. W. by W.
Northern Channel ...	1.0	S. by E.	0.6	S.	0.3	W. by S.	0.9	W. by N.
	VIII. H.		IX. H.		X. H.		XI. H.	
Great South Channel .	1.0	N. ½ W.	1.3	N. ½ W.	1.3	N. ¼ W.	0.9	N. ¼ W.
George's Shoal	1.7	N. W. by N.	1.8	N. by E.	1.6	N. N. E.	1.2	N. E. by E.
Great Eastern Channel	1.2	N. W.½ N	1.3	N. N. W.	1.2	N. by E.	0.7	N. E.
Northern Channel	1.3	N. W. by W.	1.1	N. W. by W.	0.9	N. N. W.	0.5	N. by E.

In this table the hours are tidal hours, or twelfths of the time between any two following high waters. The rates given are those for an ordinary tide of 9.8 feet at Boston, and must be increased or diminished proportionally with the range of the tide. All directions are *magnetic*.

Tides in New York Harbor.—Between seven and eight hours after the moon's transit, high water has just passed Sandy Hook with an elevation of about four and a half feet, and at the same time has advanced just inside Block Island with a height of two feet. The latter tide, traversing the Sound with increasing velocity and height, reaches Sand's Point about eleven and a half hours after the transit of the moon, and with an elevation of seven and three-fourths feet. At Hell Gate this tidal wave is met by that which entered at Sandy Hook, and which, owing to the configuration of the channel, travelled more slowly. The meeting and overlapping of these two tides causes differences between the harbor and Sound, which produces the violent currents of the East River. If a partition could be placed across Hell Gate, the difference in the *range* of the tide on its sides would sometimes amount to ten feet. As matters stand, a difference of one foot in the level is often observed, off Hallett's Point, within the space of forty yards. The westerly current through Hell Gate is commonly called the "ebb-stream," since it joins the ebb-stream of New York harbor.

TIMES AND HEIGHTS OF TIDES IN LONG ISLAND SOUND AND NEW YORK HARBOR.



Tides of the Pacific Coast.—The tides of the Pacific Coast are of a complicated character. There are generally, in each lunar day of twenty-four hours fifty-two minutes, two high and two low waters, which are unequal in height and in time in proportion to the moon's declination, differing most from each other when the moon's declination is greatest, and least when the moon is on the equator. The high and low waters generally follow each other thus: starting from the lowest low water, the tide rises to the lower of the two high waters, then falls slightly to a low water (which is often indicated merely by a long stand), then rises to the highest high water, whence it falls again to the lowest low water.

San Francisco.—The inequalities in the *heights* of successive low waters are more considerable than those of successive high waters; while, on the contrary, the inequalities in the *times* of high water are more marked than those of low. The mean difference between the heights of two successive high waters is one foot three inches, and of two successive low waters, two feet four inches. The average difference of these heights, when the moon's declination is greatest, is for the high waters two feet, and for the low waters three feet six inches. The mean variation from twelve hours and twenty-six minutes in the *interval* between two successive high waters is one hour and twelve minutes, and between two low waters fifty-three minutes. The average variations of the same interval, when the moon is farthest from the equator, are, respectively, two hours and one hour and a quarter.

"If the moon is *south* of the equator and passes the meridian in the morning, the morning high water will be higher than the afternoon high water; if it crosses in the afternoon, the afternoon high water will be the higher.

"If the moon is *north* of the equator, and passes the meridian in the morning, the afternoon high water will be the higher; if in the afternoon, the morning high water will be the higher."

The lowest of the two low waters of the day occurs about seven hours after the highest of the two high waters.

The mean difference between the height of the highest high water and of the lowest low water is five feet eleven inches, and the greatest difference is seven feet seven inches.

Gulf of Mexico.—The tides of ports in the Gulf of Mexico, westward of Cape St. George, on the north-east shore of the gulf, are usually single day tides, the rise and fall increasing or decreasing with the moon's declination.

The rise and fall being very small, the times and heights are both much influenced by the winds. Between Cape St. George and Cape Florida there are two tides during the twenty-four hours, subject to a large diurnal inequality.

The highest high and lowe t low waters occur when the greatest declination of the moon happens at full and change. The least when the moon's declination is nothing at the first or last quarter.

TO COMPUTE THE TIME OF HIGH WATER FOR PORTS OF THE UNITED STATES.

Rule.—Ascertain the time of transit of the moon for Greenwich, preceding the time of high water required, from the Nautical Almanac. Multiply the number in the column "Diff. for one hour" by the longitude of the place (in time) west of Greenwich, and add the product to the Greenwich time of transit.

N. B.—*It will frequently be necessary to use the transit for the preceding day, as the astronomical day does not end until noon of the day under consideration.*

The sum will be the time of transit at the place. To this time add the establishment of the port from the table, and the result will be the time of high water.

Example.—To find the time of high water at New York on the 6th July, 1866. From Nautical Almanac we find the time of moon's transit at Greenwich to be 18h. 31m. on the 5th of July. The longitude is about five hours, which, multiplied by 2m. 2s., the difference for one hour, gives eleven minutes as the correction to be added to the Greenwich time of transit to get the time of transit for New York, making the latter 18h. 42m. Then to 5d. 18h. 42m., time of transit at New York, add 8h. 13m., establishment of port. The sum 6d. 2h. 55m. is the time of high water.

Tide-Table for the Coast of the United States.

[COAST SURVEY.]

Place.	Time.	Mean Rise and Fall.
	h. m.	
Eastport	11.08	15.0
Southwest Harbor	11.02	10.0
Belfast Bay	11.05	9.6
Wiscasset	11.12	9.4
Portland	11.17	9.1
Portsmouth	11.23	8.6
Newburyport	11.22	8.0
Plum Island Sound	11.26	8.5
Rockport Harbor	10.57	8.4
Gloucester Harbor	11.02	9.4
Beverly Harbor	11.13	9.3
Swampscott Harbor	11.12	9.5
Boston Light	11.12	9.3
Boston	11.27	10.0
Nantucket	12.24	3.1
Edgartown	12.16	2.0
Holmes' Hole	11.43	1.7
Tarpaulin Cove	8.04	2.3
Wood's Hole, N. side	7.59	4.0
" " S. side	8.24	1.6
Bird Island Light	7.59	4.4
Dumpling Rock	7.57	3.8
Newport	7.45	3.9
Point Judith	7.32	3.1
Montauk Point	8.20	1.9
Sandy Hook	7.29	4.8
New York	8.13	4.3
LONG ISLAND SOUND.		
Watch Hill	9 00	2.7
Stonington	9.07	2.7
New London	9.28	2.6
New Haven	11.16	5.9
Bridgeport	11.11	6.5
Oyster Bay	11.07	7.3
Sand's Point	11.13	7.7
New Rochelle	11.22	7.6
Throg's Neck	11.20	7.3

Tide-Table—*Continued.*

Place.	Time.	Mean Rise and Fall.
COAST OF NEW JERSEY.	h. m.	
Cold Spring Inlet	7.32	4.4
Cape May Landing	8.19	4.8
DELAWARE BAY AND RIVER.		
Delaware Breakwater	8.00	3.5
Higbee's	8.33	4.9
Egg Island Light	9.04	6.0
Mahon's River	9.52	5.9
New Castle	11.53	6.5
Philadelphia	13.44	6.0
CHESAPEAKE BAY AND RIVERS.		
Cape Henry	7.51	6.0
Old Point Comfort	8.17	2.5
Point Lookout	12.58	1.4
Annapolis	17.04	0.9
Bodkin Light	18.08	1.0
Baltimore	18.59	1.3
James River (City Point)	14.37	2.8
Richmond	16.58	2.9
Hatteras Inlet	7.04	2.0
Beaufort	7.26	2.8
Smithville (Cape Fear)	7.19	4.5
Charleston (C. H. Wharf)	7.26	5 1
Fort Pulaski (Savannah entrance)	7.20	7.0
Savannah (Dry Dock Wharf)	8.13	6.5
St. Augustine	8.21	4.2
Cape Florida	8.34	1.5
Sand Key	8.40	1.2
Key West	9.22	1.3
Tampa Bay (Egmont Key)	11.21	1.4
Cedar Keys (Depot Key)	13.15	2.6
WESTERN COAST.		
San Diego	9.38	3.7
San Pedro	9.39	3.7
Cuyler's Harbor	9.25	3.7
San Luis Obispo	10.08	3.6
Monterey	10.22	3.4
South Turallone	10.37	3.6
San Francisco (N. Beach)	12.06	3.6
Mare Island (*San Francisco Bay*)	13.40	4.8

Tide-Table—*Continued.*

Place.	Time.	Mean Rise and Fall.
WESTERN COAST.	h. m.	
Benicia	14.10	4.5
Bodega	11.17	3.6
Humboldt Bay	12.02	4.4
Port Orford	11.26	5.1
Astoria	12.42	6.1
Nee-ah Harbor	12.38	5.6
Port Townshend	3.49	4.6
Steilacoom	4.46	9.2
Semi-ah-moo Bay	4.50	5.7

NOTE.—The mean interval has been increased by twelve hours twenty-six minutes (half a lunar day) for some of the ports in Delaware River and Chesapeake Bay, so as to show the succession of times from the mouth. Therefore, twelve hours twenty-six minutes ought to be subtracted from the establishments which are greater than that quantity before using them.

Bench-Marks Used.

Boston.—The top of the wall at the entrance to the dry dock in the Charlestown Navy Yard, 14.76 feet above mean low water.

New York.—The lower edge of a straight line, cut in a stone wall, at the head of the wooden wharf on Governor's Island, 14.51 feet above mean low water.

Old Point Comfort, Va.—A line cut in the wall of the lighthouse, one foot from the ground, on the southwest side, eleven feet above mean low water.

Charleston, S. C.—The outer and lower edge of embrasure of gun No. 3, at Castle Pinckney, 10.13 feet above mean low water.

To Determine the Rise and Fall of the Tide for any Given Time from High or Low Water.

The following table shows the relation between the heights above low water for each half-hour, for New York and for Old Point Comfort, and for spring and neap tides at each place. Units express the

total rise of high water above low water, and the figures opposite to each half-hour denote the proportional fall of the tide from high water onward to low water.

Time before or after High Water.		New York.		Old Point Comfort.	
		Springs.	Neaps.	Springs.	Neaps.
h.	m.				
0	0	1.00	1.00	1.00	1.00
0	30	.98	.98	.98	.98
1	00	.94	.93	.95	.94
1	30	.89	.86	.88	.87
2	00	.80	.72	.80	.78
2	30	.72	.59	.70	.68
3	00	.60	.45	.59	.57
3	30	.49	.31	.49	.44
4	00	.39	.19	.37	.34
4	30	.28	.10	.26	.22
5	00	.18	.02	.17	.13
5	30	.09	.00	.08	.05
6	00	.05		.03	.01
6	30	.00		.00	.00

Remarks.

Yearly Tide-Tables are now published by the United States Coast Survey, which give the computed times of high water for the most important ports of the United States, and constants to apply to these times to obtain the time of high water at the neighboring places. These tables take into account the daily and semi-monthly inequalities, and various local circumstances affecting both the times and heights of the tide, and should be purchased whenever practicable. The price is twenty-five cents per year. Similar tables are annually published by the British Admiralty for the coast of Great Britain.

For other parts of the world the tide-hours or establishments of various ports may be found in any epitome of navigation, and the time of high water may then be found by the same rule as that given for the coast of the United States, observing to correct the time of transit at Greenwich for the longitude of the place.

Tide-Signals.—In French ports, flood and ebb, and the height of the tide, are signalled at intervals by means of black balls, and by flags; these are hoisted on a mast crossed by a yard.

A ball at the intersection of the mast and yard indicates a depth of 3 mètres or 9¾ feet. Each ball *below* this, and in the line of the mast, represents an additional height of 1 mètre or 3¼ feet; but each ball *above* it, an additional height of 2 mètres or 6½ feet A ball hoisted at the yard-arm and seen to the left of the mast indicates .25 mètres or ¾ of a foot additional; but seen to the right of the mast, .5 mètres, or 1⅝ feet additional.

In order to show the state of the tide in respect to flood and ebb, a white flag crossed with black from corner to corner, and a black pendant will be used. One or both of these will be flying at the mast head, so long as there are 2 mètres or 6½ feet water in the channel; thus, the pendant above the flag indicates flood—the flag alone, high water—and the pendant below the flag, ebb.

A red flag at the mast-head indicates that the state of the tide is such that a vessel cannot enter.

TIDAL OBSERVATIONS.

Instructions for the Use of the Tide-Pole.

FOR all localities which are sheltered from the swell of the sea, a tide-pole may be used. It consists of a staff graduated upward in feet and tenths, and which is erected in a vertical position, with its zero mark below the level of the lowest tide. To this staff a painted batten is sometimes secured, conspicuously marked, the alternate feet being painted black on the white ground, and *vice versa;* such a batten may be read from a great distance. The zero of the tide-pole should be connected with the bench-mark, or permanent point of reference by levellings. A line of sight from the bench-mark across the tide-pole to the sea horizon is a good level line. The time is noted for every rise and fall of a certain distance, or the state of the gauge marked for equal intervals of time, say fifteen minutes, care being taken to determine as near as possible the *times of high and low* water, by taking a mean of the times at which *the water was at* equal heights before or after high or low water.

The time of high water is thus found on a similar principle to that by which the time of apparent noon is found, viz., by adding the times of the equal heights of the water (instead of the sun) together, and dividing by 2.

The state of the wind and barometer should always be noted.

If in port at the time of the full and change of the moon, it is advisable to observe especially the high and low water on that day, remembering also that the greatest rise and fall may not occur until several tides after full or change. The times and heights of high and low water should be observed successively by both day and *night;* and the watch or clock by which the times are taken should always show *mean time at the place.*

The greater the number of results obtained, the more accurate will be the value deduced from them; if, however, circumstances will not admit of a continuous series of tidal observations being made, the day and night high and low waters that occur on those days when the moon's transit takes place between 11 h. and 2 h., and 6 h. and 3 h., should be preferred, as from the former the Tide-Hour (establishment) and the mean Spring Range are obtained, and from the latter, the mean Neap Range is known.

If there should be no available spot for the erection of the tide-pole, or if the tide-pole is not near enough to be noted from the ship (which may often be done by means of a telescope), a good idea of the rise and fall may be obtained by noting the depth alongside, if the ship be moored, with a well-stretched lead-line, carefully marked for the purpose, in feet and inches.

From the tidal observations, a daily tide-table may be made, showing for every hour of the day the number of feet to be subtracted from the soundings taken to reduce them to low water. All soundings should be reduced at once, and if possible by the officer who obtained them. If the ship's stay is not long enough to get the times of high water at full and change, that fact should be noted on the chart, and the rise and fall termed approximate. To determine the rise and fall of the tide, and to reduce soundings accurately, require considerable judgment, patience, and experience.

For ordinary purposes, the following table for reducing Soundings to the Mean Low Water Spring Tide will be found sufficiently correct.

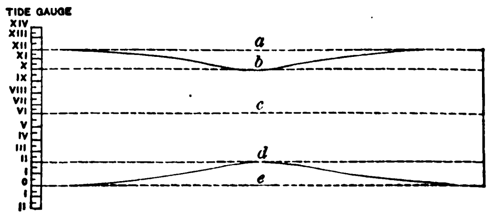
At Spring Tides.

Deduct of the full rise at springs	1st h. $\frac{11}{12}$	2d h. $\frac{3}{4}$	3d h. $\frac{1}{2}$	4th h. $\frac{1}{4}$	5th h. $\frac{1}{12}$	6th h. 0	before and after high water.

At Neap Tides.

Deduct of the ordinary rise at springs	1st h. $\frac{4}{6}$	2d h. $\frac{3}{4}$	3d h. $\frac{1}{2}$	4th h. $\frac{1}{4}$	5th h. $\frac{1}{6}$	6th h. 0	before and after high water.

The following diagram may explain the terms *Spring Rise*, *Neap Rise*, and *Neap Range*.



a=Mean level of high water ordinary springs.
b= " " " " " " neaps.
c=Half tide or mean level of the sea both at springs and neaps.
d=Mean level of low water ordinary neaps.
e= " " " " " " springs.

Example.

Spring rise (or mean spring range) $=e$ to $a=12$ ft.
Neap rise, ... $=e$ to $b=10$ ft.
Neap range, ... $=d$ to $b=$ 8 ft.

Tide-Gauges.—Where the surface of the water is much disturbed, or when nice observations are required, a glass tube, with a float inside, is secured to the face of the staff. The lower end of the tube is to be partially closed by a cork with a hole through it, and the tube must be long enough to extend several feet below the surface of the water, so that all undulations will be excluded. In places where there is great range of tide, and where the swell of the sea is considerable, making observations by means of the tide-pole inconvenient, the *box-gauge* may be employed. It consists of a box, closed at the bottom, containing a graduated rod attached to a copper float, which is free to move by the action of the tide. The rod is graduated downward, and is arranged to be read either at the top of the box or at some convenient opening in the side. The place in either case is called the *reading point*, and is to be referred to the bench-mark by levelling. It is also necessary to record the distance from the zero of the rod to the water-line of the float, in order to compute the elevation of the bench-mark above the surface of the water. The water is admitted through holes on the sides and near the bottom, and these should be only large enough to admit the water freely; care is necessary to prevent their being clogged by weeds and debris.

A self-registering apparatus is generally attached to the box-gauge, so arranged that the flow carries a pencil by which a continuous curve, representing the successive changes in the height of the water, is traced on paper wrapped about a cylinder revolved by clock-work. The scale is such, that every hour is represented by one inch, and is pricked into the paper by points on the cylinder which moves the paper forward. A continuous sheet, sufficient for the record of a whole month, is put on the tide-gauge at one time.

In ports where interruptions are experienced in winter, from the box becoming clogged with ice, various devices are resorted to for overcoming this difficulty; sometimes a heating apparatus is used to maintain a temperature above the freezing-point in the box. An arrangement in use at Boston is called an "Arctic Tide-Gauge," and has compared well with the ordinary float-gauge. It consists of an iron tube, about four inches in diameter, bolted to a pile or wharf. It is open at the top, and has a nipple at its lower end, to which is attached an elastic bag supported by a cage. Glycerine is poured into it from the top of the tube, and rises and falls in the tube in proportion to *the varying height* and pressure of the column of

water above the elastic bag, the difference in the height of the two columns being in proportion to the difference of the specific gravity of the water and the glycerine. A copper tube, about three inches in diameter, and of a length a little greater than the range of the tide, floats in the glycerine within the iron tube. It is open at the top and closed at the bottom, and if left free would rise and fall with the changes in level of the liquid. Near the top of the iron tube there are three spiral springs, fixed at the top and united at the bottom by a plate from which the copper tube is suspended. From a stem attached to, and moving with, the copper tube, a line leads over a pulley, and gives horizontal motion to the pencil carriage of the recording apparatus. As the level of the liquid changes in the annular space between the tubes, the spiral spring at the top is more or less extended.

Self-registering tide-gauges being in continuous operation, all other fluctuations of the water-level, besides that due to the tides, are likewise recorded.

The tide-curves of some coasts are frequently found indented by fluctuations produced by earthquakes.

Table for Ascertaining Velocity of Tide by Noting the Number of Seconds a Knot of 47.3 feet, measured on the Log-Line, takes to Run Out.

Time in seconds.	Rate in knots.	Time in seconds.	Rate in knots.	Time in seconds.	Rate in knots.	Time in seconds.	Rate in knots.
5	5.76	17	1.65	29	0.96	41	0.68
6	4.80	18	1.55	30	0.93	42	0.67
7	3.99	19	1.47	31	0.90	43	0.65
8	3.50	20	1.40	32	0.87	44	0.63
9	3.20	21	1.33	33	0.85	45	0.62
10	2.80	22	1.27	34	0.82	46	0.61
11	2.54	23	1.23	35	0.80	47	0.60
12	2.23	24	1.17	36	0.78	48	0.58
13	2.15	25	1.12	37	0.76	49	0.57
14	1.99	26	1.08	38	0.74		
15	1.87	27	1.04	39	0.72		
16	1.76	28	1.00	40	0.70		

NOTE.—Three or four knots should be timed, and the mean taken.

CURRENT OBSERVATIONS.

AN accurate knowledge of the velocities and directions of the currents which sweep about the coasts and harbors is of great importance to the navigator, who is therefore greatly interested in the determination, by observations, of the set and drift of tidal-currents at all stages of the flood and ebb during the several quarters of the lunar month.

Tidal currents are local in extent, being affected both in direction and velocity by the existence of obstructions, either temporary or permanent, and by the configuration of the bottom in the immediate vicinity.

The observations are very simple, and need occupy but a short time in calm weather, the results, when reduced to the mean values, being more reliable than those of a series through a semi-lunation of variable weather.

The observations should begin at slack water, and may end after twelve or twenty-four hours, at the commencement of the flood or ebb. The vessel should be anchored in the channel, and her position fixed when riding to the flood and to the ebb.

The velocity of the current should then be found every half-hour while it is strong, and more frequently as it fails, using a log-line marked in nautical miles and tenths to show the drift. The set of the current is obtained by sextant, taking the angle from the log-chip to a station on shore, and as distant as possible. If no well-determined signal is in sight, the direction of the current may be determined by compass, carefully recording the deviation. The magnetic course of the current is wanted. The local mean time of each observation, and particularly at the beginning and end of the slack, the direction and force of the wind, and the depth of water at every slack, should be recorded.

In order to reduce the current observations of a single day to the mean value, the tide-gauge must be recorded through at least a semi-lunation, including the day of current records.

The *current intervals* and the *duration* of a current are estimated from the middle time of slack water, and the interval from the transit of the moon to the time of turning may thus be determined. From *observation, it has been* found that the time of maximum ve-

locity corresponds to the middle time of the current. The time of maximum velocity for a single ebb or flood may be found from the observed times and velocities, either by interpolation, or, more accurately, by plotting the curve of velocities, upon a diagram, using the current intervals throughout the duration of the current and the velocities as co-ordinates, and the *lunar interval* of the observed maximum current then becomes known. The middle time of the rise of the tide is simultaneously observed, and its lunar interval is found, and the lunar interval of the middle time of the tide is computed from a long series of observations by taking the half sum of the mean intervals of high and low tides. The difference between these intervals is a correction to be applied to the lunar interval of the observed maximum current to find the mean lunar interval of maximum velocity.

Using the tidal observations for comparison, the drift for spring tides or for neaps may be computed from a short series of current observations by the following rule, which gives a close approximation to correct results: *The velocities of the currents for corresponding hours of different tides are to each other as the rates of rise and fall at those hours.*

The current table, if intended to accompany a sketch or chart of a harbor, should be of the annexed form.

STATION.		CURRENT TURNS AFTER MOON'S TRANSIT.		MAXIMUM VELOCITY.				DURATION.		SLACK.		REMARKS.
No.	Locality.	Flood to ebb.	Ebb to flood.	Flood.	Direction.	Ebb.	Direction.	Flood.	Ebb.	Flood to ebb.	Ebb to flood.	

TIDAL STREAMS IN THE ENGLISH CHANNEL.*

English Channel.—Off the south and southeast coasts of England are two tidal streams, known as the West and East Channel Streams, running in opposite directions at the same time; they are each about one hundred and eighty miles long, and are separated by the Straits of Dover.

The West Channel Stream runs between the west end of Dover Straits, and a line joining the Start, to the Caskets; the East Channel Stream between the east end of Dover Straits, and a line joining Lynn Wash, to the Texel. These streams both set in a direction toward Dover while the water is *rising* at that place, and away from it while it is *falling*. They also run in opposite directions to the two streams outside them, viz., the stream at the mouth of the Channel and the stream in the North Sea.

Off the mouth of the English Channel, the stream, although influenced by the indraught and outset of the Channel, will be found running to the *northward* and *eastward* while the water is *falling* at Dover; and to the *southward* and *westward* while it is *rising* at that port.

Between a line joining the Land's End to Ushant, and a line joining the Start to the Caskets, is a mixed tide, influenced by the West Channel and offing streams.

The *change* of the Channel Stream does not differ materially within its fair navigable limits. Both flood and ebb streams turn from one to two hours earlier in the bights of the coast than in the offing, of which vessels may take advantage when turning to windward.

Between the Lizard and the Start, the east-going tidal stream runs usually from about three hours before to two and a half hours after high water by the shore at Plymouth. The west-going stream runs from three and a quarter hours after to two and a half hours before high water by the shore at Plymouth.

The tides about Plymouth Sound are tolerably regular, generally running each way about six hours and ten minutes at a mean. In

* *If the tidal stream is marked three knots on the chart, and it be springs, at first hour allow one knot, second hour two knots, third hour three knots, fourth hour two knots, fifth hour one knot. Take one-third from each of these quantities if it be neaps.*

Hamoaze the flood stream continues to run up on spring tides about fifteen minutes after high water at Devonport dockyard. Abreast of Plymouth Sound, about six miles from the land, the streams are very irregular, and do not turn with the tide farther out in the offing.

There is an outset, running from S.S.E. round to S.W. by S., out of the West Bay of Portland from five hours before to four hours after high water by the shore. This stream, which forms the Portland Race, acquires such velocity as to extend far beyond Portland Bill before it turns to the eastward, leaving a strong eddy between it and the land. Having assumed its easterly course, it rushes past the pitch of the Bill at the rate of six or seven knots at springs, leaping and foaming over the broken ground of Portland Ledge with great violence.

A short distance eastward of the Ledge, this outset is met by the stream which, after high water by the shore, sets for nine and a half hours to the southwest out of the East Bay of Portland; these united streams pass on toward the Shambles, which shoal they cross obliquely, running about east with a velocity of from three to four knots.

The strong tides in the Gulf of St. Malo will influence a vessel when near the Caskets, and it is therefore necessary to *use great caution;* for the indraught is strong into the Gulf, and with a gale between N.W. and S.W. the consequences may be most disastrous.

There is a considerable indraught on both flood and ebb into all the deep bights between Portland and the Owers; the use of the lead in thick weather is therefore strictly enjoined.

In the Solent, as far west as Portland, there are what are termed the *first* and *second* high waters, probably caused by the tidal stream at Spithead.

After low water at Southampton, the tide rises there steadily for seven hours, which may be considered as the *first* or proper high water; it then ebbs for an hour about nine inches, at the end of which time it again rises, and in about one and a quarter hours reaches its former level, and sometimes higher—this is called the *second* high water. Similar first and second high waters occur off either shore of the Solent. To the mariner, the knowledge that the high water at Southampton remains nearly stationary for over two hours *may in some cases* be important.

At Spithead the eastern stream makes about two and a half hours after high water in Portsmouth harbor, and runs seven hours S.E. by S.; and the western stream about two and a half hours before high water, and runs five hours N.W. by N.

In Portsmouth harbor the flowing continues about seven hours, and a narrow stream runs in fifteen or twenty minutes after high water at the dockyard. At springs the tide runs with a velocity of four and a half knots at the entrance of the harbor.

The West and East Channel Streams *meet* in Dover Straits while the water is rising at Dover, and *separate* while it is falling. The point of meeting is not stationary, however, but moves from west to east between Beachy Head and the North Foreland. Strong west gales prolong the east stream and retard the west stream. Both streams have an average rate of three knots at springs and two knots at neap.

On approaching Boulogne at the beginning of a rising tide, recollect that the Channel Streams meet thereabouts, and *turn south* upon the French coast; so that a vessel, which on the English side would have a stream setting her *up* channel, here encounters one on her *beam*, sweeping her down toward the French shore.

At Havre, on the French coast, the high water remains stationary for one hour, with a rise and fall of three or four inches for another hour, and rises and falls only thirteen inches for the space of three hours; this long period of nearly slack water is very valuable to the traffic of the port, and allows from fifteen to twenty vessels to enter or leave the docks on the same tide.

In the Downs the northeastern stream begins about one hour twenty minutes before high water at Dover, and continues to run five hours thirty minutes; it then turns and runs in a contrary direction till two hours before the ensuing high water.

The greatest rise and fall at springs on the south coast of England is twenty-four feet at Hastings, the least being five feet at Christchurch.

At all places westward of St. Alban's Head it is high water, full and change, between five hours and six hours; and at all places eastward of the Head between eleven hours and twelve hours.

In the Irish Channel, experiments have shown that the turn of the stream over all the fair navigable portion of the Channel is nearly simultaneous, and that the *time* of the turn corresponds nearly with the time of high and low water on the shore at the entrance of Liverpool

So that it is only necessary to know the times of high and low water at that place to determine the hour when the stream of the tide will *commence* or *terminate* in any part of the Channel.

As a rough general rule, in the fair-way of both the Irish and English Channels, a vessel will be carried nine miles by the stream in a whole tide at springs, and about six miles at neaps; but near to the land, on either side, the rate of the stream greatly increases, and the direction varies.

OCEAN CURRENTS.

(Bedford.)

The currents of the ocean are properly distinguished by the different and significant names—Stream and Drift.

THE DRIFT CURRENT is merely the effect of the wind on the surface of the water; as, for example, in the region of the trade winds, where the whole surface of the sea (generally speaking) is converted into a slow current moving to leeward. A drift current is, therefore, shallow and slow, and can run in no other direction than to leeward.

THE STREAM CURRENT has been described as an accumulation of the parts of the drift into a collective mass by the intervention of some obstacle; the mass then running off by means of its own gravity, and taking the direction imposed on it by the obstacle, becomes a stream of current, and in many cases a powerful stream, pursuing its way like a vast river through the ocean.

These "oceanic rivers" may vary in breadth, like the Gulf Stream, from fifty to two hundred and fifty miles, and are sufficiently deep to be turned aside by banks which do not rise within sixty or eighty fathoms of the surface, and run with such rapidity as to be uninfluenced materially by the wind, except near their borders.

Changes of temperature of the surface water are frequently abrupt. These changes are especially marked on the edges of stream currents, as, for example, on the north and west edges of the Gulf Stream, where it is met by the Labrador current from Davis's Strait, and the two streams run nearly side by side; and again off the east coast of South America, south of Rio de la Plata, where the Brazil current is met by the cold stream from Cape Horn.

The Currents of the Atlantic Ocean.

The Arctic or Labrador	Cold.
The Gulf Stream	Warm.
The N.E. Trade Drift	
The Guinea Current	Warm.
The Equatorial Current	Cold at the beginning.
The Equatorial Counter-Current	Warm.
The Brazil Current	Warm.
The Cape Horn Current	Cold.

A general set to the northward from the Antarctic regions.

THE ARCTIC OR LABRADOR CURRENT sets from Smith's Sound through Baffin's Bay and Davis's Strait, and then forms a broad stream running parallel to the coast of Labrador; its eastern limit being in about latitude 50° N., and long. 42° W. From the parallel of 50° N., the current turns to the south and southwest, running over the Banks of Newfoundland, and then forming the cold stream that sets along the American shores between the Gulf Stream and the land. This current brings with it the large quantity of field-ice and icebergs that are found in the neighborhood of Newfoundland. On first meeting with the Gulf Stream, a portion of the Labrador Current setting to the southward becomes an undercurrent, carrying field-ice and icebergs into the warm water. Icebergs have been taken by this means as far south as the parallel of 38° N.

THE GULF STREAM.—This remarkable "ocean river" issues with great velocity, and in great volume, from a sea of unusually high temperature, and deposits a vast body of warm water in the central part of the North Atlantic Ocean; a warmer region of the atmosphere is thus formed in the midst of a colder one across two-thirds of the Atlantic, between the parallels of 35° and 45° N.

The water of the Gulf Stream is a deep indigo blue in color, and its junction with ordinary sea water distinctly marked. In moderate weather the edges are marked also by ripplings, and, in the higher latitudes, frequently by evaporation. At the surface it is divided

into several bands of higher and lower temperature, of which t axis of the stream, or line of greatest velocity, is the hottest, t temperature of the water falling rapidly in shore, and more slow outside this line; the same features are observed in a modified foi at considerable depth.

Between the axis of the Stream and the coast, the fall of tempei ture is so sudden that the line of separation has received the d tinctive name of the "cold wall," a difference of 30° at the surfa having been here observed within a cable's length. The presence warm water is, however, not always an indication that a vessel under the influence of the easterly current, as the Gulf Stream, li a swollen river, frequently overflows its banks, and a counter-curre of the returning warm water prevails; hence the westerly a southwesterly currents so often experienced to the southward a eastward of the Gulf Stream.

The warm water limits are very variable, as are also in a less degree those of the Stream, for N.E. and S.E. gales force the latt to the banks skirting the American shores, whilst N.W. and westei gales drive the Stream from the shore, so that the anomaly of t Stream running in cold water, and its absence in the warm wat has been observed.

The velocity of the Gulf Stream varies with the seasons, runni strongest in July, August, and September. On entering Flori Straits from the Gulf of Mexico, the general rate is from two a a half to four miles an hour; in the narrows of the Straits fi miles an hour has been observed in August; beyond this, to t parallel of 35°, the rate is about three and a half miles, gradual decreasing as the Stream spreads to the N.E., although, even ne the meridian of 45° W. and on the forty-third parallel, the exce tional rate of four miles an hour in August has been recorde Eastward of 35° W. it becomes the great northeasterly surface dr that is felt as far as the coast of Norway.

On issuing from the Gulf of Mexico, the Stream has a maximu temperature of 85°, or 5° to 6° above the ocean temperature due that latitude; and off the Banks of Newfoundland is higher by 2 or 30° than the adjoining ocean. The following table gives t average temperature in the axis of the Stream, or warmest band water.

	Winter.	Spring.	Summer.	Autumn.
	Deg.	Deg.	Deg.	Deg.
Florida Straits	77	78	83	82
Off Charleston	75	77	82	81
Off Cape Hatteras	72	73	80	76
S.E. of Nantucket Shoals	67	68	80	72
South of Nova Scotia	62	67	78	69

The weather in the Gulf Stream is warm, squally, and unsettled, and with S.W. or W. gales the air is sultry. Beyond its north and west limits the weather is extremely cold. The sea in bad weather is heavy and irregular.

THE GUINEA CURRENT.—The drift current setting to the southward along the West Coast of Africa, between Cape Spartel and Cape Verde, becomes after passing the latter promontory a stream current, running to the eastward along that part of the African coast comprised chiefly between Cape Roxo and the Bight of Biafra, extending southward to the third and second parallels of north latitude. Its western limit can be traced at all seasons of the year as far as the twenty-third meridian of west longitude; but, in the summer and autumn months especially, an *easterly* current, extending beyond this meridian to that of 53° W. is frequently experienced; this is probably an expansion of the Guinea Current proper, and due to influences not yet investigated.

The greatest velocity of the Guinea Current is stated to be off Cape Palmas, where, at a few miles from the shore, it has been found to run more than three knots an hour. The space separating this Current from the Equatorial is generally limited, thus representing the remarkable feature of two well-marked streams running in exactly opposite directions side by side.

For about two hundred miles from the coast between Cape Verde and Sierra Leone, winds and current change with the seasons. From June to September, squally S.W. winds prevail, with a N.E. or northerly current. From October to May, when N.E. and northerly winds prevail, a southeasterly current is experienced.

Between Sierra Leone and Cape Palmas the current is influenced

by the wind. Between May and October the current runs to the N.W., with winds south of S.W.; and S E., with winds west of S.W. In November it generally sets to the N.W., while from December to May a S.E. current it experienced.

In the Harmattan seasons (December to February), the Guinea Current near the land is checked, and in shore a westerly set is found. Heavy tornadoes have a similar effect.

THE EQUATORIAL CURRENT.—The drift current setting to the southward along the African coast, between St. Helena Bay and the river Congo, forms, after passing that river, the Equatorial Current, which in its course between the Continents of Africa and America becomes a stream current, formed of water brought from a cooler region by the prevailing southerly winds. The surface temperature in the eastern part of the Equatorial Current, is several degrees colder for a great part of the year than the adjacent Guinea Current, affording evidence of receiving waters from a remote and colder parallel.

The Equatorial current appears to attain its greatest volume and velocity during the season of the northern summer. From the African coast to about the 15th degree of west longitude, the maximum strength has been observed in June and July; westward of that meridian at successive later periods, or between July and October.

The northern boundary, or rather the well-marked line of separation between it and the Guinea current, has been well traced in the space extending from the meridian of Greenwich to 23° W., and is found to vary little at the several seasons of the year.

From Anno Bom Island to about the 15th meridian of W. longitude, the following are the average surface temperatures of the Equatorial Current:

December to March, 78° to 82°...March to July, 82° to 72°.
July to October, 72° to 75° ......October to December, 75° to 78°.

Westward of the 15th meridian, the surface temperatures at the several seasons lessen materially in their range, and the Equatorial Current gradually loses its earlier features of being a cold water stream at one particular season of the year.

THE EQUATORIAL COUNTER-CURRENT.—Between the months of July and November, the northwesterly drifts from the Equatorial Current appear to be suspended, and an easterly current prevails (probably at an expansion of the Guinea Current). Between 53° and 40° W. it attains a rate of sixty miles a day; eastward of 40° it decreases in strength; and between 30° and 20° W. it runs from thirty to fifteen miles a day.

NORTH COAST OF BRAZIL AND COAST OF GUINEA.—A great part of the Equatorial Current runs along this part of South America on its way to the West Indies. The rate of this current may vary from one-half to four miles an hour, according to the distance from middle of the stream and season of the year; it probably attains its greatest strength at one hundred or one hundred and twenty miles from the coast. This stream is about two hundred miles wide, the inner edge varying from fifteen to forty-five miles from the coast. Within a few miles of the coast, tidal streams are perceptible.

During the prevalence of N.E. winds, a current runs E.S.E. along and near the north coast of Brazil; this fact is well known to the masters of the coasters.

RIVER AMAZON.—The waters of the Amazon attain their highest elevation in May, after a gradual rising of six months' duration; and then gradually fall six months. The stream from the Amazon (the ebb) at first sets E.N.E., then inclines to N. and N.W., as it unites with the Equatorial Current, increasing the velocity of the latter. The surface of the ocean is discolored by the waters of the Amazon for a considerable distance to the northward and westward of the mouth of that river.

THE BRAZIL CURRENT is a branch of the Equatorial, setting along the coast of the South American Continent to about the parallel of 42° S., where it is met by the cold Cape Horn Current setting northward.

For about one hundred and fifty miles from the Brazilian coast, between the parallel of 10° S. and Cape Frio, the current is influenced by the wind. Between October and January it generally sets to the S.W., at the rate of twenty-five to thirty miles a day; between March and September it sets to the northward, running strong in July, when it occasionally attains a velocity of forty-eight miles a day.

Rio de la Plata.—**The currents of the Rio de la Plata are governed by the winds, the water rising with southerly and falling with northerly winds. Off the entrance they generally set to the N.N.W. before and with southerly winds, and to the S.S.E. before and with northerly, at rates varying from one to three miles an hour.**

The Currents of the Pacific Ocean.

The Aleutian.—**A cold current setting to the southward through these islands from Behring Sea.**

Japan Stream (Kuro Siwo). **The northwest trade drift current of the Pacific which flows to the westward between the parallels of 9° N. and 20° N., on reaching the eastern shores of the Philippine Islands is deflected to the northward, forming in latitude 21° N., between the meridian of 125° E. and the east coast of Formosa, the commencement of the great oceanic current known as the Kuro Siwo, or Japan Stream.**

During the Northeast Monsoon **a part of the Pacific drift current continues its course to the westward through the Bashee and Balintang Channels, joining the monsoon drift current, which sets strong to the southwestward at this season, through the Formosa Channel and China Sea.**

During the Southwest Monsoon **the drift current which flows to the northward in the China Sea and Formosa Channel, joins the Kuro Siwo, and extends the western limit of its stream to a line joining the Island of Tung Ying (on the coast of China) to Tsu Sima (in the Korea Strait); this limit is very perceptible, the waters of the Japan Stream being of a dark blue color, whilst that of the colder water of the coast of China is of a pale green; the difference in temperature of the two streams is also very marked.**

The main body of the Kuro Siwo is joined at this season by the monsoon drift-current of the China Sea, which also sets to the northeast through the Bashee and Balintang Channels, and, being augmented in force, flows rapidly to the northward along the east coast of Formosa, passing between the north end of that island and the Meiaco Sima group, as far as the parallel of 26° N., where it turns to the eastward, and continues in a northeasterly direction to the westward of the Liu-Kiu Islands until it reaches the southern point of

Japan. Here an offshoot of the main Stream passes to the northward, through the Korea Strait, into the Japan Sea; the main body of the Stream, however, continues its course, and trending still more to the eastward, flows in an E.N.E. direction through Van Dieman's Strait, the numerous channels between the islands north of the Linschoten group, and along the southern shores of the islands of Kiusiu and Sikok, forming races and tide-rips, often resembling heavy breakers on reefs or shoals. The Kuro Siwo attains its greatest velocity when abreast of Sikok, where it has been known to set 100 miles in 24 hours; its usual velocity in this locality, however, being from two to three knots an hour.

Continuing its course along the south coast of the Island of Nipon, past the Gulf of Yedo, the Kuro Siwo flows through the chain of islands lying south of that Gulf in the numerous channels between which its direction is found to be variable and, under tidal influence, as far as latitude 36½° N.; the northern edge of the Japan stream then leaves the coast of Nipon and runs N.E., while a cold current setting to the southward along the shores of Kamschatka and the Kuril Islands, intervenes between the Kuro Siwo and the northeastern shores of Nipon and Yezo.

At about the meridian of 150° E., the Kuro Siwo divides; one part flowing to the northward, and taking the name of Kamschatka current, is felt as far as the Aleutian Islands and Behring Strait, whilst the greater portion of the Stream continues in an easterly direction between the parallels of 32° N. and 41° N., as far as the meridian of 160° E., where it is deflected to the southeastward as far as the meridian of 180°, there losing its identity in the drift currents of the North Pacific Ocean, which flow to the north and northeastward.

The maximum temperature of the Stream during the S.W. monsoon is 86°, and its northwestern edge is strongly marked by a sudden thermal change in the water of from 12° to 20°; but the southern and eastern limits are much less distinctly marked.

In the summer months, viz., from May to September inclusive, the mean temperature of the Kuro Siwo is 82°, or 7° higher than the mean temperature of the ocean in the same latitude.

In the months of April and October, hot and cold belts are found alternating in the stream, the temperature of which belts differ from 7° to 10°; whilst during the winter months, viz., from November to

arch, the temperature of the Stream, attaining in the latitude of ormosa a mean of 74°, falls on reaching the shores of Japan to 3°, or below the temperature of the ocean at the same season.

THE KAMSCHATKA CURRENT is a branch of the Kuro Siwo, from which it separates in the parallel of 40° N., on the meridian of 150° E., and flows to the northeastward, as far as 51° N., at an average rate of eighteen miles a day, its breadth being about two hundred miles; a branch then trends to the eastward, toward the Aleutian Islands. Between the parallels of 51° N. and 60° N. there is a difficulty in tracing this current, but beyond 60° N. it is again found setting to the northeast; passing west of St. Matthew Island and east of St. Lawrence Island, it flows along the American coast through Behring Strait into the Arctic Ocean. In the Strait the mean temperature of its waters (52°) is 15° higher than that of the waters along the Asiatic shore. The channel between St. Lawrence Island and the coast of Asia is hampered with ice until July, while the coast of America is free from ice in the month of April.

THE OYA SIWO.—A counter-current of cold water, called the Oya Siwo sets to the southward, along the southeast coast of Kamschatka and the Kuril Islands, and is felt as far south as Inaboye Saki. It varies in velocity and extent in the different seasons, being much stronger in the winter than in the summer. Except between the Kuril Islands, past Cape Noyshap, and through the Tsugar Strait, the force of the cold stream is about eighteen miles a day; through these narrows, however, it sweeps occasionally with great speed, particularly during or after a strong northeasterly wind

The temperature of the Oya Siwo is from 10° to 15° lower than that of the Kuro Siwo, varying according to the season.

THE DRIFT OF THE N. E. TRADE sets across the North Pacific Ocean, between the parallels of 9° and 22° N. A portion of this drift (to the northward of the Sandwich Islands) turns to the northwest, northward, and northeastward, carrying a considerable body of warm water into the great bight between Vancouver Island and the peninsula of Alaska.

THE MEXICAN CURRENT is a continuation of the drift setting to the southward along the Californian coast. It runs along the Mexican coast as far as the Gulf of Fonseca, where it is met and recurved to

the westward by the set northward and westward from the Pacific counter-current.

THE PACIFIC COUNTER-CURRENT.—A large portion of the Equatorial current sets to the W.N.W. along the north coast of New Guinea. On reaching the shores of the Malay Archipelago, this current recurves, and, flowing to the eastward, right across the Pacific Ocean, between the parallels of about 4° to 8°, forms the Pacific Counter-Current. On reaching the American coast it appears to divide, the main portion curving to the northward, meeting and turning the Mexican Stream about the Gulf of Fonseca, from which point the streams appear to run together to the westward; and the other part turns to the southward, meeting the Peruvian stream between the American coast and the Galapagos Islands.

THE PERUVIAN CURRENT is a cold stream setting to the northward along the coast of South America; between the Galapagos Islands and the continent it divides, one part running to the northward, toward and then round the Bay of Panama, the other curving to the westward, and forming the commencement of the Equatorial Stream.

The meeting of the Mexican, Pacific Counter, and Peruvian Currents in the bight of Panama, accounts for the variable weather, with the tropical squalls and conflicting currents, experienced in that vicinity.

THE EQUATORIAL CURRENT, which is considered as a continuation of the Peruvian Stream, sets across the Pacific between the parallels of 4° N. and 10° S. About the meridian of 180° it appears to divide, one portion running to the northwest along the coast of New Guinea, the other trending to the southwest along the Australian coast.

THE AUSTRALIAN CURRENT is a branch of the Equatorial, setting along the east coast of Australia as far as the meridian of Sydney, where the off-shore portion is met and curved back to the east and northeast by the cold Antarctic Current setting to the northward.

THE S. E. TRADE DRIFT of the Pacific sets across the ocean, turning to the southward about the meridian of Tahiti; and to the southward of latitude 30° S. the direction of the waters appear to be toward Cape Horn.

In the Pacific, as in the Atlantic Ocean, there is a steady set to the northward from the Antarctic regions, setting northeast, in the neighborhood of Cape Horn.

NOTE.—The currents of the Indian Ocean, and those in the eastern passages to China, require careful attention from mariners navigating those seas, but a description of the currents is considered to be outside the limits of a work of this character.

GENERAL HYDROGRAPHIC INFORMATION.

THE sailor has often the opportunity of giving great assistance to his fellow-seamen, by forwarding to the Hydrographic Office any information from which existing charts and sailing directions may be corrected.

The language of such communications should be concise, seamanlike, and descriptive of such matters as the wants of a sailor are likely to need; as the appearance of the coast on making the land, with its prominent headlands and mountain peaks, giving their estimated height, and the distance from which they can be seen; or, if the coast be low, describing remarkable trees, sand-hills, or any natural or artificial beacons that may help to distinguish the locality; the outlying dangers, with the means of clearing them; and the general character of the soundings, with the nature of the bottom.

Give information as to where pilots are to be obtained; the special signals; pilot regulations and pilotage; where to get steam-tugs; the best anchorage or nearest harbor of refuge to make for in case of bad weather; or in an extreme case, as a leak, etc., describe the best place to lay the ship aground, and the best time of tide for so doing.

Describe all lights, buoys, and beacons, and notice any convenient rivers or creeks for wooding or watering.

Give general directions for sailing, steaming, or working by day, by night, and in a fog. State the prevailing winds and their seasons; land and sea breezes when they predominate. Time balls, tide signals and fog-signals are to be described, currents to be noted, and whether permanent or affected by periodical winds. When rivers of any importance are visited, give the points to which the tide reaches, and to which they are navigable, with the velocity of the

stream at ebb and flood, and how it may be affected by periodical rains.

In describing seaports, give so much of nautical statistics as will enable seamen to judge of their importance, and probable supplies that may be obtained: as, where fresh water is to be found, in what manner, and its quality; facilities for coaling a steamer, and price of coal; whether wood can be obtained in quantity sufficient for steaming purposes, or to combine with coal; dock accommodation, both graving and floating, width of entrance gates, and depth over sill at high water; facilities for the repair of a vessel, or the machinery of a steamer; conveniences for heaving down; power of largest crane or shears; quarantine regulations; hospitals for sailors; shipping offices for seamen; prevailing diseases, if of a virulent character, seasons at which they may be expected, and precautions for guarding against them; diet, clothing, etc.; any special custom-house regulations; holidays, etc.; current money, and its usual value in English money; population; number of fishermen and seafaring men; foreign consuls or consular agents; means of communication by steam vessels, by rail, by telegraph, etc.

Tides.—For both springs and neaps give the height of high water above the level of low water ordinary springs. The times and heights of high and low water should be taken when the moon passes the meridian of the place between 11 h. and 2 h., and also between 6 h. and 8 h. If the tides are practically affected by diurnal inequality, it should be especially noticed. In describing tide streams in the offing, it is desirable to use the terms "east" or "west-going stream," as the case may be, in order to avoid confusing the "flood" and "ebb" streams.

Currents.—In general, during a passage, the difference between the position as determined by observation and that deduced from the dead reckoning has been adopted as the effect of a single current acting throughout the day, whereas it is probable that in some parts of the ocean the ship will have passed through different streams during the twenty-four hours, and have been affected by various impulses. To form consistent views on a subject so deeply interesting, it is desirable where the vessel may be crossing the boundaries of opposing currents (or where ripplings, discolored water, flocks of birds, or shoals of fish are observed) that systematic observations

for latitude and time should be made. In determining the amount and velocity of an ocean current, due consideration should be given to the probable effects of bad steerage, to the action of the swell and sea upon the vessel, and also to any changes in the variation and deviation of the compass.

Trade Winds and Monsoons.—The annual periods and geographical limits of the trade winds, monsoons, and rains, and the times and peculiarities of the daily sea and land breezes, afford ample scope for investigation. Observations on the hurricanes, or revolving storms of the Atlantic and Indian Oceans, and the typhoons in the China Sea, are also much required.

Lights.—Lights and light-houses claim particular attention, and any case of a new light, or error in description of one already established, should be immediately reported. Every detail that can be useful to the mariner should be obtained, and in describing a new light, give its character and brilliancy; the intervals of its flashes, if revolving; whether the illuminating apparatus be dioptric or catoptric, and its order or class; likewise the bearings from seaward on which the light is either visible or obscured; the height of the centre of the lantern above the high water of ordinary spring tides; the height also of the building from the base to vane; its form, color, or other peculiarity.

Vigias.—Numerous imaginary dangers are traditionally inserted in all ocean charts, and from which they might be expunged if ample evidence of their non-existence within wide limits could be obtained. Pieces of wreck, dirty icebergs, dead whales, shoals of fish, and sundry other floating substances, account for most of these reported rocks. In the neighborhood of such imagined dangers, some deep sea casts of the lead would be well bestowed, and the observant seaman will keep his eyes open to every unusual appearance in the sea, such as partial ripplings, discolored water, flocks of birds or shoals of fish, as they may, if not caused by the meeting of currents, be indications of some change in the nature or depth of the bottom. In such cases a deep sea cast should be obtained. Before reporting new rocks or dangers, their existence and position should be well determined; for when once doubtful dangers are placed upon the chart, there is considerable difficulty in removing them.

Variation of the Compass.—As the lines of equal variation traced on a chart are valuable to seamen, not only for the ordinary purposes of navigation, but also to determine by comparison the varying error of their compasses, pains should be bestowed in multiplying observations at sea for the variation of the compass, more especially when the track of the vessel passes through those spaces where the variation changes rapidly, as off the coasts of Newfoundland and Nova Scotia. These observations should be tabulated, with the date, ship's position, direction of ship's head, and tables of deviation of the compass as determined at sea or in port.

Meridian Distances.—In determining the longitudes of imperfectly known places, meridian distances, well measured, will be very valuable. As meridian distances depend upon places whose positions are well determined, it should always be stated from what point the distance was measured; the time elapsed between the rating of the chronometers; and number of chronometers used. When a meridian distance is measured to a point or island on an unsurveyed coast, a rough plan of the immediate neighborhood should also be provided.

Courses and Bearings are invariably to be given by compass, corrected for the deviation. All dangers, especially those on which a vessel has struck or grounded, should always be determined by two or more sextant angles of well-selected objects. A careful magnetic bearing must also be given of one of the objects used. If bearings only are observed, care should be taken that they do not cut each other at a less angle than 30°.

In Sailing along a Coast of which there are no Reliable Charts, angles, bearings, and *true bearings** with astronomical observations, should be taken, to correct the errors of the existing chart and to acquire some knowledge of the nature of the coast. Latitudes from altitudes of stars north and south of the zenith should be obtained, with frequent observations in the Northern hemisphere

* The problem of *true bearing* consists in measuring the angular distance between the sun's limb and the object of which the true bearing is required. This angle, reduced to the horizontal angle by right-angled spherics, and applied to the azimuth of the sun, will give the true bearing of the object. The sun should be in a favorable position for taking an *azimuth, and the* angular distance measured should always be *double the altitude of the sun.*

of the Pole star. The dead reckoning should be very carefully kept, and carefully worked, and frequent comparisons made with the astronomical positions to determine the amount of current that may be affecting the vessel.

If circumstances permit of a coast being examined, *a true bearing* from amplitude may be obtained at sunrise, and angles measured between conspicuous objects; noting the direction of the ship's head; the course to be steered; the patent log, if in use; and the time. Another set of angles, between the points used at sunrise and *a true bearing* from azimuth, may be taken when the forenoon observations are obtained, other objects ahead being selected to continue the work by; a third set may be taken at noon, and the observations continued on similar principles in the afternoon and evening. In thus obtaining the sets of angles and bearings for a running survey, it must be remembered that the ship must either be stopped or hove to, or the observations must be taken simultaneously. Bearings of all objects in transit should be taken, and the direction of the ship's head and her courses carefully noted. If no current has been experienced, the courses steered and distances run will form bases from which an attempt at projection may be made; or from the true positions, determined by observations, the bearings may be laid off.

To Reduce Soundings for the State of the Tide.

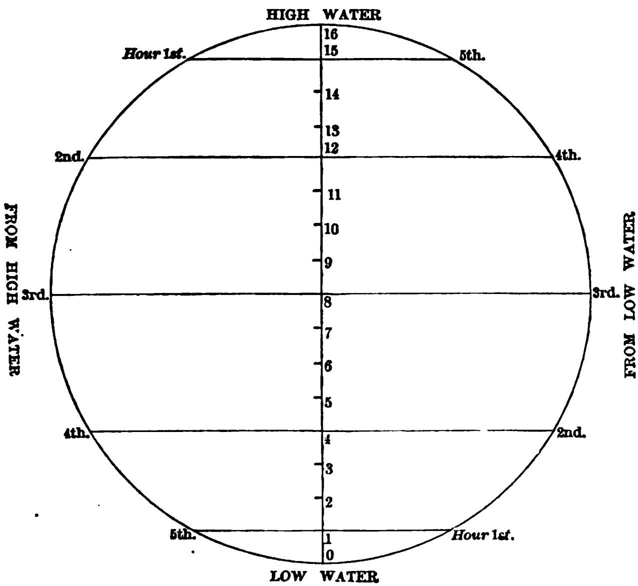
In the open sea the tides require about six hours and a quarter to rise from low water to high water, and the same interval to fall from high to low water. If the rise or fall was equal throughout, a simple proportional part of the rise due to the time of tide would at once give the reduction of the sounding to the low water of that day, or that due to the range of that tide.

But the water does not rise in equal proportions. There is very little rise in the first or last hours; in the second hour the increase is considerable; in the third and fourth hours it is still greater; and then it begins to take off in the same ratio as it increased.

The correct amount for every hour, and for various ranges, is given in the following table; but, to give a ready idea of the law, a figure is annexed which represents with sufficient exactness all that is *necessary for practical* purposes. The circumference of the circle is

divided into six equal parts on each side, corresponding with the hours of the tide; and the diameter divided into proportional parts, corresponding to a given range of the tide, which has been taken as *sixteen* feet in the figure.

By connecting the segments of the circle by straight lines drawn across the figure, it will be seen that they intersect the diameter at certain divisions of the range. These are the correct quantities respectively due to each hour's rise or fall of such a tide from low to high water, and *vice versâ*.



An examination of these quantities will show that in the *first hour* the tide rises about one-sixteenth of the whole range or rise.

In the *second hour*, about three-sixteenths.
In the *third hour*, about four-sixteenths.
In the *fourth hour*, about four-sixteenths.
In the *fifth hour*, about three-sixteenths.
In the *last hour*, about one-sixteenth.

So that at about two hours from low or high water the tide has risen or fallen *one-fourth part* of its whole range; at three hours, or about *half* tide, it has risen just *half* its range; and at four hours it has risen *three-fourths* of the whole range.

As these proportions will always hold good, be the rise great or small, it will be well for the seaman to bear them in his mind, or to draw the figure upon a card and keep it in his pocket. But he must also bear in mind that those quantities respectively taken from a sounding will only reduce it to the low water of the tide of *that day*, which may chance to be a *neap tide*, whilst the depth marked upon all charts are given at *spring tides*, so that a further correction on this account is necessary; and this is made by adding to the quantity just found half the difference between the range of the day of observation and half the spring range marked upon the chart.

The depths marked on charts being given at *low water spring tides*, casts of the lead taken at any other time of tide, or upon any other day than *full* and *change*, require a correction before they can be compared with those depths; and if this correction is neglected in seas where the tides are large, the soundings, instead of being a guide, can tend only to mislead.

The correction is very simple, and no seaman need be ignorant of it. To *half* the *spring range* marked upon the *chart* apply the correction from the table, and the result is the quantity to be *taken* from the sounding obtained.

To use the table, the rise of the tide and time of high water for the day must be computed or obtained from tide tables.

When the time of high water is known subtract from it your own time, and call the result *time from high water*.

Divide the height of the tide by 2, and call the remainder half-range. With these quantities enter the table and take out the corresponding quantity, which add or subtract, as directed, to the *half-spring range* marked upon the chart. The result is the correction to be made to the sounding.

To Find the Correction to be Applied to Soundings Taken at any Hour between High and Low Water.

Half daily range of tide.	TIME FROM HIGH WATER.												
	H. M. 0 0	H. M. 0 30	H. M. 1 0	H. M. 1 30	H. M. 2 0	H. M. 2 30	H. M. 3 0	H. M. 3 30	H. M. 4 0	H. M. 4 30	H. M. 5 0	H. M. 5 30	H. M. 6 0
	ADD.						UBTRACT.						
FEET.	F. I.	F. I.	F. I.	F. I.	F. I.	F. I.	F. I.	F. I.	F. I.	F. I.	F. I.	F. I.	F. I.
3	3 0	2 11	2 7	2 1	1 6	0 9	0 0	0 9	1 6	2 1	2 7	2 11	3 0
4	4 0	3 10	3 6	2 10	2 0	1 0	0 0	1 0	2 0	2 10	3 6	3 10	4 0
5	5 0	4 10	4 4	3 6	2 6	1 3	0 0	1 3	2 6	3 6	4 4	4 10	5 0
6	6 0	5 10	5 2	4 3	3 0	1 7	0 0	1 7	3 0	4 3	5 2	5 10	6 0
7	7 0	6 9	6 1	4 11	3 6	1 10	0 0	1 10	3 6	4 11	6 1	6 9	7 0
8	8 0	7 9	6 11	5 8	4 0	2 1	0 0	2 1	4 0	5 8	6 11	7 9	8 0
9	9 0	8 8	7 9	6 4	4 6	2 4	0 0	2 4	4 6	6 4	7 9	8 8	9 0
10	10 0	9 8	8 8	7 1	5 0	2 7	0 0	2 7	5 0	7 1	8 8	9 8	10 0
11	11 0	10 8	9 6	7 9	5 6	2 10	0 0	2 10	5 6	7 9	9 6	10 8	11 0
12	12 0	11 7	10 5	8 6	6 0	3 1	0 0	3 1	6 0	8 6	10 5	11 7	12 0
13	13 0	12 7	11 3	9 2	6 6	3 4	0 0	3 4	6 6	9 2	11 3	12 7	13 0
14	14 0	13 6	12 1	9 11	7 0	3 7	0 0	3 7	7 0	9 11	12 1	13 6	14 0
15	15 0	14 6	13 0	10 7	7 6	3 11	0 0	3 11	7 6	10 7	13 0	14 6	15 0
16	16 0	15 5	13 10	11 4	8 0	4 2	0 0	4 2	8 0	11 4	13 10	15 5	16 0
17	17 0	16 5	14 9	12 0	8 6	4 5	0 0	4 5	8 6	12 0	14 9	16 5	17 0
18	18 0	17 5	15 7	12 9	9 0	4 8	0 0	4 8	9 0	12 9	15 7	17 5	18 0
19	19 0	18 4	16 5	13 5	9 6	4 11	0 0	4 11	9 6	13 5	16 5	18 4	19 0
20	20 0	19 4	17 4	14 2	10 0	5 2	0 0	5 2	10 0	14 2	17 4	19 4	20 0
21	21 0	20 3	18 2	14 10	10 6	5 5	0 0	5 5	10 6	14 10	18 2	20 3	21 0
22	22 0	21 3	19 1	15 7	11 0	5 8	0 0	5 8	11 9	15 7	19 1	21 3	22 0
23	23 0	22 3	19 11	16 3	11 6	5 11	0 0	5 11	11 6	16 3	19 11	22 3	23 0
24	24 0	23 2	20 9	17 0	12 0	6 2	0 0	6 2	12 0	17 0	20 9	23 2	24 0

Example I.—A vessel off Liverpool strikes soundings in 8 fathoms at 8.35 P.M., on September 13, 1876.

What will be her corrected sounding to compare with the chart?

	H. M.
By Admiralty Tide Tables, Time H. W. at Liverpool....	10 35 P.M.
Time of sounding	8 35 P.M.
Time from H. W...........	2 00

Height at Liverpool, 25 feet 5 inches.
One-half of same is 12 feet $8\frac{1}{2}$ inches=half-range of the day.

From table (additive)........	6 feet 6 inches.
Half-spring range from chart..	15 " 0 "
	21 feet 6 inches, or $3\frac{1}{2}$ fathoms.

	Fathoms.
Depth by lead	8
Correction	$3\frac{1}{2}$
Showing the depth for comparison to be.....	$4\frac{1}{2}$

So that the depth, to compare with the chart, is only $4\frac{1}{2}$ fathoms instead of 8 fathoms.

Example II.—A vessel having to cross Victoria Bar, Liverpool, at 8.35 P.M., on September 13, 1876, requires to know what water she will have over the bar.

	H.	M.	
By Admiralty Tide Tables, September 13th—Time from H. W................................	2	0	
	Ft.	In.	
Half-range on that day..........................	12	8	
By table, with these quantities, the correction is ..	6	6	additive.
Half-spring range..................................	15	0	
Correction	21	6	
By chart, depth on Victoria Bar at L. W. Springs..	11	0	
Depth on bar at 2 h. from H. W., Sept. 13th...	32	6	or $5\frac{1}{2}$ fms.

Meridians Adopted in the Construction of Charts.

The United States, Great Britain, Germany, Russia, Sweden, Denmark, Norway, Holland, and Austria adopt the meridian of Greenwich.

France adopts the meridian of Paris, in longitude 2° 20′ 9.4″ E. of Greenwich.

Spain adopts the meridian of San Fernando, Cadiz, in longitude 6° 12′ 16″ W. of Greenwich.

The Pulkowa Observatory, sometimes referred to in Russian Charts, is in longitude 30° 19′ 40″ E. of Greenwich.

The Royal Observatory of Naples, sometimes referred to in Italian Charts, is in longitude 14° 14′ 31.3″ E. of Greenwich.

Signs and Abbreviations used on Charts.

Quality of Bottom.

black,	*blk.*	coral,	*crl.*	ground,	*grd.*	red,	*rd.*	speckled,	*spk.*
blue,	*b.*	dark,	*d.*	hard,	*h.*	rock,	*r.*	stiff,	*stf.*
broken,	*brk.* or *bkn.*	fine,	*f.*	mud,	*m.*	rotten,	*rot.*	stones,	*st.*
brown,	*br.*	gray,	*gy.*	ooze,	*oz.*	sand,	*s.*	weed,	*wd.*
clay,	*cl.*	gravel,	*g.*	oysters,	*oys.*	shells,	*sh.*	white,	*w.* or *wh.*
coarse,	*c.—co.*	green,	*gn.*	pebbles.	*peb.*	soft,	*sft.*	yellow,	*y.*

BUOYS are marked: B. (*black*); Cheq. (*chequered*); H. S. (*horizontal stripes*); R. (*red*); W. (*white*); B. W. (*black and white*); B. R. (*black and red*); R. W. (*red and white*); V. S. (*vertical stripes*). A *green* buoy indicates the position of a wreck.

LIGHTS are indicated by a *dot*, colored *yellow* with a *red spot* in the middle; if there is any uncertainty about its character it is simply marked Lt.; Lt. F.=*light fixed;* Lt. Fl.=*light flashing;* Lt. Int.=*light intermittent;* Lt. Rev.=*light revolving;* Lt. F. and Fl.=*light fixed and flashing;* Flg. Lt.=*floating light;* Lt. Ves.=*light vessel;* the color of the light is expressed in full: as *red; blue; green; white; red and white; white, red, and green;* when *no color* is expressed it is taken to be *white.*

CURRENTS are indicated by a *feathered arrow*, and the direction of the arrow shows the direction of current.

FLOOD tide *stream* is shown by an arrow feathered on one side; EBB tide *stream* by unfeathered arrow.

ROCKS just under water are indicated by a small dotted circle with cross in centre; rocks awash or just above water are indicated by a dotted circle with a dot or dots in centre; a dotted circle with a numeral in it *signifies a shoal* with the feet or fathoms of water

over it. Rock, island, or shoal with E. D., signifies *existence doubtful;* P. D., *position doubtful* though known to exist.

COMPASS.—If the N. and S. line of the compass is not *on* or *parallel with* a meridian it is *magnetic*, according to the variation in the locality; if it coincides with the meridian it is *true*.

Fms.=fathoms; Ft.=foot or feet; H. W.=high water; H. W. F. and C.=high water at full and change of moon; L. W.=low water; Np.=neaps; Rf.=reef; Rk.=rock; Sh.=shoal; Sp.=springs; Vis.=visible; + Obs. Spot=place where observation was made. Anchorage is indicated by an anchor, and the depth is generally close by.

Soundings are reduced to *mean* low water of ordinary spring tides, and are expressed in fathoms and fractions of a fathom, or in feet and fractions of a foot.

The velocity of tide is expressed in knots and fractions of a knot.

A number with a line and dot above signifies no bottom at the depth given, thus $\overline{\dot{1}23}$=no bottom at 123 fathoms.

All heights are in feet above high water ordinary springs, and where there is no tide, above the mean level of the sea.

The rise of tide is measured from the mean low water level of ordinary springs; the range of tide from the low water of one tide to the high water of the following tide.

All distances are in nautical miles; a cable's length is the tenth part of the nautical mile.

A fathom=6 feet; a nautical mile=1.1528 statute mile; a statute mile=.8674 nautical mile; 13 nautical miles=15 statute miles, *very nearly.*

Soundings on Foreign Charts.

Danish and Norwegian............	Favn	6.175 Eng. feet=	1.029 Eng. fathom.
Dutch	Vadem....	5.575 "	0.929 "
Dutch (recent)....................	Elle.......	3.281 "	0.547 "
French	Mètre	3.281 "	0.547 "
French (old).....................	Brasse	5.329 "	0.888 "
Portuguese	Braça.....	6.004 "	1.000 "
Prussian	Faden	5.906 "	0.984 "
Russian, the Eng. fathom and foot.			
Spanish	Metro	3.281 "	0.547 "
Spanish (old)....................	Braza.....	5.492 "	0.915 "
Swedish	Famn.....	5.843 "	0.974 "

Quality of Bottom.

As expressed on Charts of Different Nations.

English.	French.	Italian.	Spanish.	German.
Clay ....*cl.*	Argile........*A.*	Argila.	Arcillo or Barro	Lehm.......*L.*
Coral ....*crl.*	Corail......*Cor.*	Corállo.	Coral ....*cl.*	Korallen....*K.*
Gravel ....*g.*	Gravier .....*Gr.*	Rena or Ghiaja.	Cascájo .....*Co.*	Grob sand .*g.s.*
Mud ....*m.*	Vase.........*V.*	Fango.	Fango or Luno *F.*	Schlemm..*Sch.*
Rock ....*rk.*	Roche ....*R.*	Roccia.	Piedra or Roca *P.*	Fels ....*F.*
Sand ....*s.*	Sable.........*S.*	Sábia or Aréna.	Arena........*A.*	Sand........*S.*
Shells ....*sh*	Coquille....*Coq.*	Conchiglia.	Conchuela ...*ca.*	Muschel ....*M.*
Stones ....*st.*	Pierre........*P.*	Pietre.	Piedra .... ..*P.*	Stein.
Weed ....*wd.*	Herbe ....*H.*	Alga.	Alga ....*A.*	Gras........*G.*
Fine ....*f.*	Fin ....*fin.*	Fino.	Fina ....*f.*	Fein ....*f.*
Coarse........*c.*	Gros..........*g.*	Grosso.	Escalroso.	Grob ....*g.*
Stiff........*stf.*	Dure ....*d.*	Tenace.	Tenaz.	Zahe........*Z.*
Soft... .....*sft.*	Molle ....*m.*	Molle.	Muelle.	Weich...... *W.*
Black.......*blk.*	Noire ....*n.*	Nero.	Negro.	Schwarz .*schw.*
Red ....*rd.*	Rouge ....*r.*	Rosse.	Rojo.	Roth.
Yellow........*y.*	Jaune........*j.*	Giallo.	Amarillo.	Gelb.

Section 4.

NSTRUCTION AND USE OF MERCATOR'S CHART.

DETERMINING POSITIONS.

MEASURING DISTANCES AND HEIGHTS.

CALCULATE TIME OF TWILIGHT, SUNSET, AND SUNRISE, ETC.

FINDING THE STARS.

SHAPING THE COURSE.

GREAT CIRCLE SAILING.

LATITUDE BY MERIDIAN ALTITUDE, POLARIS, ETC.

GITUDE FROM SINGLE AND EQUAL ALTITUDES; LONGITUDE AT NOON AND AT SUNSET OR SUNRISE; LATITUDE AND LONGITUDE AT NOON.

REMARKS ON SUMNER'S METHOD.

OBSERVATIONS AT SEA AND ON SHORE.

CHRONOMETERS.

TIME.

A MERCATOR'S CHART.

ON a Mercator's chart, the equator and parallels of latitude are represented by parallel straight lines, and the meridians also by parallel straight lines, at right angles with the equator. Two parallels, generally those which bound the chart, are divided into equal parts, commencing at some meridian and using some convenient scale to represent degrees, and subdivided to 10′, 1′, or some other part of a degree, according to the scale used.

Two meridians, generally the extremes, are also divided into degrees, and subdivided like the parallels of latitude, but by a scale increasing steadily with the latitude; so that any degree on such meridian, instead of being equal to a degree of the equator, is an *augmented* degree, or augmented difference of 1° of latitude derived from a table of meridianal parts.

The meridian is graduated by laying off from the equator the augmented latitudes; or from some parallel of latitude the augmented *difference of latitude* for each degree and part of a degree, using the same scale of equal parts as for the equator.

Thus on such a chart, the length of one degree

In latitude		0° is	60′	of the equator.			
"	"	10° "	61′	"	"		
"	"	20° "	64′	"	"		
"	"	30° "	69′	"	"		
"	"	40° "	78′	"	"		
"	"	50° "	93′	"	"	etc.	

And the augmented difference of latitude

From 0° to 10° is 603′ = 10° 03′ of the equator.
" 10° " 20° " 622′ = 10° 22′ " "

As on other charts, parallels of latitude and meridians are delineated at convenient intervals; shore lines of continents and islands, harbors and rivers, places, etc., are plotted; and such configurations of the land represented as may be required.

The meridians on this chart being parallel, arcs of parallels of latitude are represented as equal to the corresponding arcs of the equator; that is, each is expanded in the proportion of the secant of its

latitude to 1 ; and it may be shown that very small portions of the meridians are expanded in the same proportion.

Mercator's projection has been compared to a cylinder unrolled—the cylinder being such an one as we might suppose to circumscribe the globe at the equator.

A Mercator's chart presents two decided advantages over all others for nautical purposes, namely:

The ship's track is represented by a straight line.

The angle which this track makes with any meridian is the course.

To Find the Course from one point to another on the chart, draw a line or lay the edge of a ruler through the two points, and measure its angle with any meridian. In practice, the line is generally referred, by means of parallel rulers, to the centre of one of the compass diagrams delineated on the chart, when the course may be at once read off.

To Find the Distance.—Take off the distance between the two places by a pair of dividers, and refer it to the augmented scale on the graduated meridians, using the same middle latitude on the scale as of the line between the places.

To Find the Latitude of a Place on the Chart.—With the dividers take the distance of the place from the nearest parallel ; refer this distance to one of the graduated meridians, placing one point of the dividers on the same parallel, and the other point upward or downward as required ; read off the latitude at the position of the latter point.

To Find the Longitude of a Place on the Chart.—With the dividers take the distance of the place from the nearest meridian ; refer this distance to one of the graduated parallels, placing one point of the dividers on the same meridian, and the other point to the right or left of it as required ; read off the longitude at the position of the latter point.

To Mark the Ship's Place on the Chart.—With the dividers take from the graduated meridian the given latitude ; mark this on the meridian nearest to the given longitude ; lay the edge of a pair of parallel rulers on a near parallel, and work one side of them to *the exact latitude* you have marked on the meridian ; then, with the

dividers, take the given longitude from the graduated parallel; lay this down along the edge of the parallel rulers which already mark the latitude, and you have the ship's place.

When near the land, a ship's place may be laid down by means of what are known as *cross-bearings*, which in the case of an iron vessel or steamer must always be corrected for the *deviation* peculiar to the direction of the ship's head at the time.

A GENERAL CHART takes in a large expanse of the ocean and bounding land, an entire sea, or a considerable extent of coast line with its contiguous waters. The parallels and meridians are delineated on it, the lights are marked, the soundings, variation of the compass, and such other details as the scale of projection will admit of. The compasses are often true, but sometimes *correct* magnetic. It is a *large scale* or *small scale* chart according to the extent of coast and sea delineated.

A PLAN is a chart that comprises a detached portion of a general chart on a large scale, as a harbor, roadstead, bay, the entrance to a river, an island, a small part of the sea where the navigation is intricate, etc. On it are given the lights and buoys, the soundings and bottom, the leading marks, the courses through channels, the dangers to be avoided, the variation of the compass, the tidal establishment of the port, the rise of tide at springs and neaps, and everything that tends to facilitate the navigation of the locality; the compass is *correct* magnetic, and the scale to which the chart is drawn is recorded. Sometimes the scale of miles is given.

Charts are generally drawn so that the top is the North, the bottom the South, the side to the right the East, and the side to the left the West. If, for a special purpose, the chart is drawn on the *diagonal scale*, a reference to one of the compasses—the North point of which is always denoted by a device, as a fleur-de-lis, arrow, or star—will at once show the North and South, and consequently the East and West.

DETERMINING POSITIONS, ETC.

Cross-Bearings.

THE most useful method of determining upon the chart a vessel's exact position, *is by means of two* compass-bearings of any two

well-defined objects in view, which may also be delineated upon the chart, such as light-houses, light-ships, points or headlands, etc.

The bearings of the two selected objects being observed, draw lines through them on the chart in the directions of the bearings; the point of intersection of these lines is the place of the ship.

If precision is required, the *deviation* proper to the *ship's head* at the time must be employed. When the difference of bearings is nearly a right angle, this is the most complete of all methods; but if the difference is less than 20°, or near 180°, a small error in the bearing will cause a great error in the distance, and, therefore, the ship's position will be uncertain.

Various Other Methods.

When **in sight of land,** a common method of **fixing a ship or boat is by** observing two objects that are in **transit**—*i.e.*, **situated in the same line as the ship or boat—and** taking an angle between them **and** some well-known object to the **right** or left, taking care that the **angle** measured is not less than 30°. **A line** is then ruled **through the objects in** transit, and from some point in it the observed angle is laid off in the direction of the third object; **a line ruled** through that object parallel to the **line** forming the angle **will intersect the** line ruled through the objects in **transit** at the position of the ship. ***Example.***—Two points, **D and L, whose** positions are known, **are observed to** be in transit from **a** ship at P, **and an** angle, S P S, of 51° is measured between them and **a** third point, S; through D and L a line, D L P, is drawn, and at a point, P, in that line an angle, D P S, equal to 51° is laid off towards S, and a line, P S, drawn; then through S a line, S P, is drawn parallel to S P, cutting D L P in P, the required position.

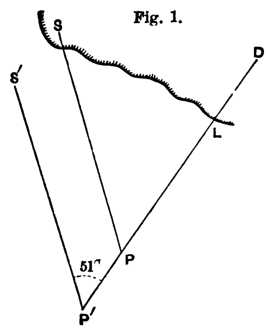


Fig. 1.

A bearing may also be taken of either S or D; **this bearing is**

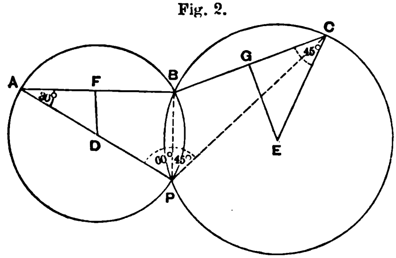
then ruled upon the chart, and the position of the observer fixed by projecting in a similar manner the angle measured between the objects.

The position of the ship may also be fixed by projecting angles measured from her between three objects on shore, whose bearings and distances from each other are known.

In the selection of three objects by which to fix a position, the middle object should, if possible, be the nearest to the observer, or the three objects should be in or near the same straight line, or the observer's position should be within the triangle formed by the objects. If the objects and the position of the observer lie in or near the circumference of the same circle, the position cannot be fixed without the assistance of a bearing of one of the objects.

Projecting by Circles. *Case* I.—Let A, B, and C be three objects on a chart (see Fig. 2); it is required to fix the position of a ship, P, by angles; the one measured between C and B being 45°, and that between B and A being 60°.

Fig. 2.



Join A B, B C, and bisect them in the points F and G, erecting the perpendiculars F D, G E, on the same side of the objects as that on which the ship lies. Then at A make the angle F A D =30°, the complement of the angle measured between B and A, and at C make the angle G C E=45°, the complement of the angle measured between C and B, and draw lines, A D, C E, cutting the perpendiculars F D, G E, in D and E. From D and E, as centres, describe the circles A B P and C B P, and the intersection of their circumferences at P will be the position of the ship.

Case II.—Should the angle be greater than 90°, erect the perpendicular on the opposite side of the line joining the objects to that on which *the ship lies*, and making the angle F A D=90° –

the angle subtended, proceed as before (see Fig. 3), where the angle measured between C and B is 70°, and that between B and A is 120°.

By the Straight Line Projection. *Case* I.—At B (see Fig. 4) on the same side of the objects as that on which the ship lies, make

Fig. 3.

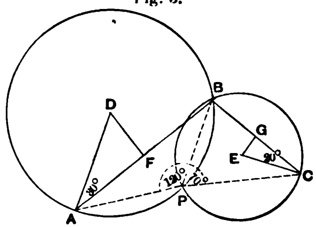
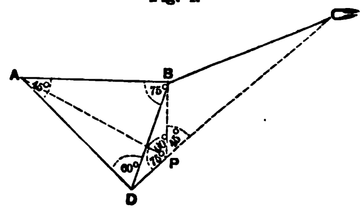


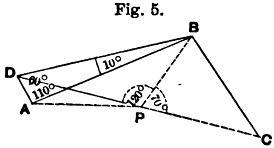
Fig. 4.



the angle A B D=75° or 180°−(60°+45°); at A make the angle B A D=45°, or the angle subtended by the side B C; join C D, and on C D make the angle B P C=45°; the point P will be the position required.

Case II.—When the sum of the angles measured is more than 180° (see Fig. 5) at B, on the opposite side of A B to that on which the ship lies, make the angle A B D =10°, or (120° +70°)−180°; at A make the angle B A D=110°, or 180°−70°, the angle subtended by B C; join C D, and on C D make the angle B P C=70°; the point P will be the position required.

Fig. 5.



A vessel's position may also be determined by laying off the angles taken between three known objects on a piece of tracing paper with a protractor. Rule upon the tracing paper a straight line, representing the line from the ship to the centre object, and from any point on this line set off the angles observed to the right and left, and draw the lines on the tracing paper; lay the tracing paper

on the chart, and move the tracing paper over the surface of the chart until the three lines pass through the respective objects; that done, the point on the tracing paper from which the angles were laid off will be the position of the ship.

By the Soundings.—When the depth of water is not great, and also varies sensibly with the distance from the land, this distance may be found from the chart by means of the soundings.

Soundings are very regular upon the American coast, and in thick or foggy weather, *by allowing for the state of the tide*, the position of a vessel may be determined.

By a Bearing and the Latitude or Longitude of the Ship.—When either the latitude or longitude are known, the true bearing of an object, such as a point of land, about four points from the parallel of latitude or meridian of longitude, will determine accurately the position of the ship.*

MEASURING DISTANCES.

Raper's Method of Determining Distances at Sea.

The distance of high land, whose height is known, may be found by measuring its altitude with a sextant.

When angles observed with the sextant are not more than 5°, they should be taken both on and off the arc, added together, and divided by 2. The result is an angle free of index error.

---

* Back bearings should invariably be obtained when navigating coastwise, especially at night. These bearings, plotted on the chart, will show the course made good, and serve to indicate any deviation due to currents or other causes.

Again, it is well to scan the chart before making a night passage along a coast, and to select the line of least soundings, which may serve as a guide to the vessel's distance from shore. This line may be taken as a "curve of safety," and the vessel kept outside of that depth.

Had either of these precautions been observed in the case of the ill-fated Huron, her false position would have been evident long before striking. The bearings would have shown that she was being set on shore instead of making good the course laid down; and had the "curve of safety" been previously determined and adhered to, the danger would have been avoided. At that particular part of the coast the twenty fathom curve is the least one that could serve as a reliable guide, all soundings inside that line being useless for the determination of the distance of the land.

Rule.—To the log. cos. of the dip of the height of the summi ob-served, add the log. cos. of the difference between the altitude and the dip of the spectator. The sum is the log. cos. of an arc, rom which subtract the said difference, and the remainder is the dist ance in miles, or minutes of a degree.

NOTE.—The altitude must exceed the dip of the spectator.

Example.—The summit of Mount Etna is observed to be 1° 30 th above the horizon; the height of the eye 20 feet. Required distance.

Log. cos. dip of Mount Etna* 9.9997 74
Log. cos. $(1° 30' - 4' 17'') = 1° 26'$ 9.9998 34

$2° 20''$ Log. cos....... 9.99963 8
$-1\ \ 26$

54 miles approximate distance.

The summit and the horizon being both raised by refraction in proportion to their distances, the altitude must be corrected by this rule: *Subtract from the altitude observed* one-twelfth of the distance, and add to the remainder one-twelfth of the dip.

One-twelfth of 54′, or 4′ 30″, being taken from 1° 30′; and one twelfth of 5′, or 25″, being added, gives the true altitude 1° 25′ 55″; and the sum worked over again with this altitude gives the distance, 56 miles.

---

* The log. cos. of the dip of some principal points of high land are here given for convenience, and the log of any intermediate height may be found by simple proportion.

Peak of Teneriffe (12,172)	9.999747
Mount Etna (10,885)	9.999774
St. Antonio, Cape Verde Is. (7,398)	9.999846
Mount Athos (6,774)	9.999859
Pico Ruivo, Madeira (6,188)	9.999872
Mount Ida (5,800)	9.999879
Black Mountain, Cephalonia (5,382)	9.999888
Volcano, Guadaloupe (5,108)	9.999894
Table Mountain, Cape of Good Hope (3,904)	9.999910
Mount Vesuvius (3,878)	9.999920
Diana Peak, St. Helena (2,687)	9.999944
Mount St. Peter, Ascension (2,217)	9.969954
Rock of Gibraltar (1,437)	9.999970

Measuring Distances by Sound.

Sound travels at the rate of 1,090 feet in a second of time when the air is at freezing point, or 32° Fahrenheit. This rate is accelerated by 1.19 feet for each degree of Fahrenheit above that temperature, giving 1,123 feet (or 374 yards) velocity per second for a mean temperature of 60°, which may be used for all ordinary purposes.

Example.—Thermometer showing 80° Fahr.

Observed flash of gun at	8 h.	25 m.	33 sec.
Heard report	8	25	40
			7 sec.

80°
32°
———
48° difference.

At 32° sound travels	1,090 feet.
1.19 acceleration × 48	57 "
At 80° sound travels	1,147 feet.

$$1,147 \times 7 = 8,029 \text{ feet, or } 2,676 \text{ yards.}$$

As sound is accelerated or retarded by wind, the distance should be measured on a calm day, or when there is not much wind, in case guns are fired from one end only of the distance. The gun fired should have extreme elevation given to it; and, if possible, guns should be fired from each end of the required distance.

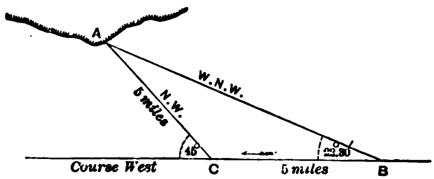
The best method of measuring distances by sound is, first, to ascertain the number of times that the watch to be used beats in a minute of time. Most pocket chronometers beat 5 times in 2 seconds, or 150 beats to a minute; ordinary watches vary.

The number of beats of the watch ascertained, it is easy to find the number of yards that sound travels in that beat, making due allowance for the temperature. At 60° Fahr., for instance, sound travels 150 yards in one beat of a watch beating 150 times in one minute. That number multiplied by the number of beats observed, will give the distance required.

A simple method of counting the beats is by binding the watch close to the ear by means of a pocket-handkerchief; this leaves hands and eye free to use glass and note-book. The observer begins to count on seeing the *flash*, finishing with the *report* of the gun. Velocity of sound in water is about four times, and through solids averages ten times, that in air.

Useful Methods of Determining Distance from a Light-house, or other Object, when Running along the Land.—Take a bearing of the object and note the time; see how many points it differs from the course; when this difference is doubled, the ship will be as far from the object as she has run in the interval.

Make due allowance for current.



Example.— Steering west, going 10 knots, at 9.45 A. M.; a light-house A, bore W.N.W. Difference between bearing and course=2 points. Stood on until it bore N.W. (double the difference), time 10.15 A. M.

Distance run=5 miles=distance of light-house.

THE BOW AND BEAM bearing, so much used in coastwise navigation, is merely a special case of this method.

When a light, or other fixed object, is *nearly abeam*, its distance may be found as follows:

Note the time that elapses while the light alters its bearing two and a half points. Twice the distance run in this time is the distance of the light.

Example.—A light when nearly abeam bore W. by N., and in twenty minutes time it bore W. by S. ½ S., ship steaming eleven knots, tide one knot with us; required the distance of the light.

Answer.—The bearing altered two and a half points while the ship ran four knots over the ground, therefore the distance is eight miles.

N.B.—The value of these thumb rules is all the greater for not requiring the aid of a chart.

Table for Finding the Distance of an Object by Two Bearings and the Distance Run Between Them.

Difference between the course and the SECOND bearing. Points.	Difference between the course and the FIRST bearing—points. 2	2½	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10	10½
4	1.00																	
4½	0.81	1.23																
5	0.69	1.00	1.45															
5½	0.60	0.85	1.17	1.66														
6	0.54	0.74	1.00	1.35	1.85													
6½	0.49	0.67	0.88	1.14	1.50	2.02												
7	0.46	0.61	0.79	1.00	1.27	1.64	2.17											
7½	0.43	0.57	0.72	0.90	1.11	1.39	1.77	2.30										
8	0.41	0.53	0.67	0.82	1.00	1.22	1.50	1.87	2.41									
8½	0.40	0.51	0.63	0.76	0.92	1.09	1.31	1.58	1.96	2.50								
9	0.39	0.49	0.60	0.72	0.85	1.00	1.18	1.39	1.66	2.03	2.56							
9½	0.38	0.48	0.58	0.69	0.80	0.92	1.08	1.25	1.46	1.72	2.08	2.60						
10	0.38	0.47	0.57	0.66	0.76	0.88	1.00	1.14	1.31	1.51	1.76	2.11	2.61					
10½	0.38	0.47	0.56	0.65	0.74	0.84	0.94	1.06	1.19	1.35	1.55	1.79	2.12	2.60				
11	0.39	0.47	0.56	0.64	0.72	0.81	0.90	1.00	1.11	1.24	1.39	1.57	1.80	2.11	2.56			
11½	0.40	0.48	0.56	0.63	0.71	0.79	0.87	0.95	1.05	1.15	1.27	1.41	1.58	1.79	2.08	2.50		
12	0.41	0.49	0.57	0.64	0.71	0.78	0.85	0.92	1.00	1.08	1.18	1.29	1.41	1.57	1.76	2.03	2.41	
12½	0.45	0.51	0.58	0.65	0.71	0.77	0.83	0.90	0.97	1.03	1.11	1.20	1.29	1.41	1.55	1.72	1.96	2.30

RULE.—Multiply the distance run in the interval between the two bearings by the number found in the table under the difference between the course and first bearing, and opposite the difference between the course and second bearing. The product is the distance at the time the second bearing was taken.

Example.—A light-house, when first seen, bore W.N.W.; after running W. by S. sixteen miles, it bore N. ½ W. Required its distance when the second bearing was taken.

Difference between course and first bearing .... =8 points.
Difference between course and second bearing......... =8½ points.
Corresponding tabular number........... .... =0.63
And 16 miles × 0.63 = 10.08 miles, the distance required.

N.B.—Make due allowance for current.

Table of Distances at which Objects can be Seen at Sea According to their Respective Elevations and the Elevation of the Eye of the Observer.

Heights in feet.	Distances, in statute or English miles.	Distances, in geographic or nautical miles.	Heights, in feet.	Distances, in statute or English miles.	Distances, in geographic or nautical miles.	Heights, in feet.	Distances, in statute or English miles.	Distances, in geographic or nautical miles.
5	2.958	2.565	70	11.067	9.598	250	20.916	18.14
10	4.184	3.628	75	11.456	9.935	300	22.912	19.87
15	5.123	4.443	80	11.832	10.26	350	24.748	21.46
20	5.916	5.130	85	12.196	10.57	400	26.457	22.94
25	6.614	5.736	90	12.549	10.88	450	28.062	24.33
30	7.245	6.283	95	12.893	11.18	500	29.580	25.65
35	7.826	6.787	100	13.228	11.47	550	31.024	26.90
40	8.366	7.255	110	13.874	12.03	600	32.403	28.10
45	8.874	7.696	120	14.490	12.56	650	33.726	29.25
50	9.354	8.112	130	15.083	13.08	700	35.000	30.28
55	9.811	8.509	140	15.652	13.57	800	37.416	32.45
60	10.246	8.886	150	16.201	14.05	900	39.836	34.54
65	10.665	9.249	200	18.708	16.22	1,000	41.833	36.28

Example.—A tower 150 feet high will be visible, to an observer whose eye is elevated 15 feet above the water, 18½ nautical miles; thus, from the table:

15 feet elevation; distance visible.... 4.443 nautical miles.
150 " " " " .... 14.05 " "

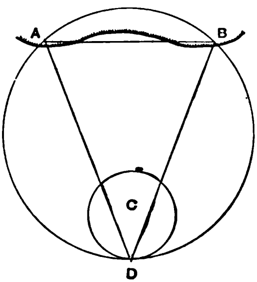
18.493

The distance at which an object is visible above the horizon at sea is proportional to the square root of its height. The effect of refraction is to increase the distance of visibility by about one-eleventh of that which results from the earth's curvature alone. This table is calculated with regard to refraction, and shows the *distance at which an object of a given height is visible above the sea horizon.*

The Danger Angle.

The application of this is based on the well-known principle, that angles in the same segment of a circle are equal to one another.

Example.—Suppose C a well-known danger under water, A and B two well-defined points. It is required to pass clear of C at a distance of five cables lengths.



Describe a circle round C, with a radius of five cables, and on the circumference, to seaward of the danger, take a point D. Join A B, A D, and B D, and describe a circle about the triangle A D B. The angle A D B, in this case 50°, is the danger angle, which being set upon a sextant, will, so long as kept on, place the ship on the segment of the circle A D B, and clear of the danger C. Should the angle increase, the vessel will be inside of the circle, and *vice versa.*

Departure.

Determining the place of a ship with reference to a point of land, or other position of known latitude and longitude, is called *taking a departure.*

The position of the ship with respect to a point of land or other fixed and conspicuous object is defined by the *direction* in which she lies, and her *distance* from it.

The *direction* of the ship from the land, being the opposite of the bearing of the land from the ship, is furnished at once by the compass, but the *distance* from the point, when it cannot be estimated with sufficient precision, must be deduced by means of some one of the foregoing *methods for determining* distance.

14

Table of Masthead Angles.

Distance in yards.	Height of Masthead. 80 feet.	90 feet.	100 feet.	110 feet.	120 feet.	130 feet.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
100	14 55 53	16 41 57	18 26 6	20 8 11	21 48 5	23 25 43
150	10 4 51	11 18 36	12 31 44	13 44 11	14 55 54	16 6 49
200	7 35 40	8 31 51	9 27 44	10 23 20	11 18 36	12 13 30
250	6 5 19	6 50 34	7 35 40	8 20 38	9 5 25	9 50 1
300	5 4 46	5 42 38	6 20 25	6 58 6	7 35 41	8 13 9
350	4 21 25	4 53 57	5 26 25	5 58 50	6 31 12	7 3 28
400	3 48 51	4 17 21	4 45 49	5 14 15	5 42 39	6 10 58
450	3 23 28	3 48 51	4 14 11	4 39 30	5 4 47	5 30 1
500	3 3 11	3 26 1	3 48 50	4 11 39	4 34 26	4 57 12
550	2 46 33	3 7 20	3 28 6	3 38 51	4 9 35	4 30 18
600	2 32 41	2 51 45	3 10 47	3 29 49	3 48 51	4 7 51
650	2 20 57	2 38 33	2 56 8	3 13 43	3 31 17	3 48 51
700	2 10 54	2 27 15	2 43 35	2 59 55	3 16 14	3 32 32
750	2 2 11	2 17 26	2 32 41	2 47 56	3 3 10	3 18 24
800	1 54 33	2 8 51	2 23 9	2 37 27	2 51 45	3 6 2
850	1 47 49	2 1 17	2 14 45	2 28 12	2 41 40	2 55 7
900	1 41 50	1 54 33	2 7 16	2 19 59	2 32 41	2 45 23
950	1 36 28	1 48 32	2 0 34	2 12 37	2 24 40	2 36 42
1000	1 31 39	1 43 6	1 54 33	2 6 0	2 17 26	2 28 53
1050	1 27 17	1 38 12	1 49 6	2 0 0	2 10 54	2 21 48
1100	1 23 19	1 33 44	1 44 8	1 54 33	2 4 57	2 15 21
1150	1 19 42	1 29 40	1 39 37	1 49 33	1 59 32	2 9 28

NOTE.—When observed masthead angles are not more than 5° they should be *taken both on and off* the arc of the sextant, and the mean will give angle free of *index error.*

Table of Masthead Angles—*Continued.*

Distance in Yards.	Height of Masthead.					
	140 feet.	150 feet.	160 feet.	170 feet.	180 feet.	190 feet.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
100	25 1 0	26 33 54	28 4 21	29 32 19	30 57 50	32 20 51
150	17 16 55	18 26 6	19 34 24	20 41 44	21 48 6	22 53 26
200	13 8 2	14 2 11	14 55 53	15 49 9	16 41 57	17 34 17
250	10 34 25	11 18 36	12 2 33	12 46 16	13 29 45	14 12 57
300	8 50 30	9 27 44	10 4 50	10 41 47	11 18 36	11 55 15
350	7 35 40	8 7 49	8 39 51	9 11 48	9 43 40	10 15 25
400	6 39 16	7 7 30	7 35 40	8 3 47	8 31 51	8 59 50
450	5 55 14	6 20 25	6 45 33	7 10 38	7 35 41	3 0 40
500	5 19 56	5 42 39	6 5 19	6 27 57	6 50 34	7 13 9
550	4 50 59	5 11 40	5 32 19	5 53 57	6 13 33	6 34 8
600	4 26 51	4 45 49	5 4 47	5 23 43	5 42 38	6 1 32
650	4 6 23	4 23 55	4 41 26	4 58 57	5 16 26	5 33 54
700	3 48 51	4 5 8	4 21 25	4 37 41	4 53 57	5 10 11
750	3 23 38	3 48 51	4 4 3	4 19 15	4 34 26	4 49 37
800	3 20 19	3 34 35	3 48 51	4 3 6	4 17 21	4 31 35
850	3 8 33	3 21 59	3 35 25	3 48 51	4 2 16	4 15 40
900	2 58 6	3 10 47	3 23 29	3 36 10	3 48 51	4 1 31
950	2 48 44	3 0 46	3 12 48	3 24 49	3 36 50	3 48 51
1000	2 40 19	2 51 45	3 3 10	3 14 36	3 26 1	3 37 26
1050	2 32 41	2 43 35	2 54 28	3 5 21	3 16 14	3 27 6
1100	2 25 45	2 33 9	2 46 33	2 56 56	3 7 20	3 17 43
1150	2 19 26	2 29 22	2 39 19	2 49 17	2 19 12	3 9 8

NOTE.—When observed masthead angles are not more than 5° they should be taken both *on and off the arc of the sextant*, and the mean will give angle free of index error.

Table of Masthead Angles—*Continued.*

Distance in yards.	Height of Masthead. 80 feet.	90 feet.	100 feet.	110 feet.	120 feet.	130 feet.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
1200	1 16 23	1 25 56	1 35 28	1 45 1	1 54 33	2 4 5
1250	1 13 20	1 22 29	1 31 39	1 40 49	1 49 58	1 59 8
1300	1 10 31	1 19 19	1 28 8	1 36 56	1 45 45	1 54 33
1350	1 7 54	1 16 23	1 24 52	1 33 21	1 41 50	1 50 18
1400	1 5 28	1 13 39	1 21 50	1 30 1	1 38 12	1 46 22
1450	1 3 13	1 11 7	1 19 1	1 26 55	1 34 49	1 42 43
1500	1 1 7	1 8 45	1 16 23	1 24 1	1 31 39	1 39 17
1550	0 59 8	1 6 32	1 13 55	1 21 19	1 28 42	1 36 5
1600	0 57 18	1 4 27	1 11 37	1 18 46	1 25 56	1 33 5
1650	0 55 33	1 2 30	1 9 26	1 16 23	1 23 19	1 30 16
1700	0 53 55	1 0 39	1 7 24	1 14 8	1 20 53	1 27 37
1750	0 52 23	0 58 55	1 5 28	1 12 1	1 18 34	1 25 6
1800	0 50 56	0 57 18	1 3 39	1 10 1	1 16 23	1 22 45
1850	0 49 33	0 55 44	1 1 56	1 8 7	1 14 19	1 20 30
1900	0 48 15	0 54 16	1 0 18	1 6 20	1 12 22	1 18 23
1950	0 47 1	0 52 53	0 58 46	1 4 38	1 10 31	1 16 23
2000	0 45 50	0 51 34	0 57 17	1 3 1	1 8 45	1 14 28
2500	0 36 40	0 41 15	0 45 50	0 50 25	0 55 0	0 59 35
3000	0 30 24	0 34 23	0 38 12	0 42 1	0 45 50	0 49 39
3500	0 26 12	0 29 28	0 32 44	0 36 1	0 39 17	0 42 34
4000	0 22 55	0 25 47	0 28 39	0 31 31	0 34 23	0 37 14
4500	0 20 22	0 22 55	0 25 28	0 28 1	0 30 33	0 33 6
5000	0 18 20	0 20 38	0 22 55	0 25 12	0 27 30	0 29 48
5500	0 16 40	0 18 45	0 20 50	0 22 55	0 25 0	0 27 5
6000	0 15 16	0 17 11	0 19 6	0 21 0	0 22 55	0 24 50

NOTE.—When observed masthead angles are not more than 5° they should b *taken both on and off* the arc of the sextant, and the mean will give angle free o *idex error.*

Table of Masthead Angles—*Continued.*

Distance in yards.	Height of Masthead.					
	140 feet.	150 feet.	160 feet.	170 feet.	180 feet.	190 feet.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
1200	2 13 37	2 23 9	2 32 41	2 42 13	2 51 45	3 1 16
1250	2 8 17	2 17 26	2 26 35	2 35 44	2 44 53	2 54 2
1300	2 3 21	2 12 9	2 20 57	2 29 45	2 38 33	2 47 21
1350	1 58 47	2 7 16	2 15 45	2 24 13	2 32 41	2 41 9
1400	1 54 33	2 2 43	2 10 54	2 19 4	2 27 15	2 35 25
1450	1 50 36	1 58 30	2 6 23	2 14 17	2 22 10	2 30 4
1500	1 46 55	1 54 33	2 2 11	2 9 48	2 17 26	2 25 4
1550	1 43 28	1 50 51	1 58 14	2 5 37	2 13 1	2 20 23
1600	1 40 12	1 47 24	1 54 33	2 1 42	2 8 52	2 16 1
1650	1 37 12	1 44 8	1 51 5	1 58 1	2 4 57	2 11 53
1700	1 34 21	1 41 5	1 47 49	1 54 33	2 1 17	2 8 1
1750	1 31 39	1 38 12	1 44 44	1 51 16	1 57 49	2 4 21
1800	1 29 6	1 35 28	1 41 50	1 48 12	1 54 33	2 0 54
1850	1 26 42	1 32 53	1 39 5	1 45 16	1 51 27	1 57 39
1900	1 24 25	1 30 27	1 36 28	1 42 30	1 48 31	1 54 33
1950	1 22 15	1 28 8	1 34 0	1 39 52	1 45 45	1 51 37
2000	1 20 12	1 25 56	1 31 39	1 37 22	1 43 6	1 48 50
2500	1 4 10	1 8 45	1 13 20	1 17 55	1 22 30	1 27 4
3000	0 53 28	0 57 17	1 1 6	1 4 56	1 8 45	1 12 34
3500	0 45 50	0 49 7	0 52 23	0 55 39	0 58 56	1 2 12
4000	0 40 6	0 42 58	0 45 50	0 48 42	0 51 34	0 54 26
4500	0 35 39	0 38 12	0 40 45	0 43 17	0 45 50	0 48 23
5000	0 32 5	0 34 23	0 36 40	0 38 58	0 41 15	0 43 33
5500	0 29 10	0 31 15	0 33 20	0 35 25	0 37 30	0 39 35
6000	0 26 55	0 28 39	0 30 33	0 32 28	0 34 23	0 36 17

NOTE.—When observed masthead angles are not more than 5° they should be taken both *on and off* the arc of the sextant, and the mean will give angle free of index error.

Time Required for a Vessel to Cross a Field of Fire of 50°.

(*Ordnance Manual.*)

Velocity of the ship.	Distance in Cable's Lengths.					
	2	4	6	8	10	12
	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.
6 knots	2 02	4 04	6 06	8 08	10 10	12 12
8 "	1 30	3 00	4 30	6 00	7 30	9 00
10 "	1 12	2 24	3 26	4 48	6 00	7 12
12 "	1 00	2 00	3 00	4 00	5 00	6 00
14 "	0 52	1 44	2 36	3 28	4 20	5 12
16 "	0 46	1 32	2 18	3 04	3 50	4 36
18 "	0 40	1 20	2 00	2 40	3 20	4 00

Methods of Ascertaining from a Fort or Ship the Distance of an Enemy's Ship.

When the height of the enemy's masthead above the water-line is known, the *table of masthead angles* will give the distance; but in the case of monitors without masts, gun-boats, mortar-boats, etc., this method is not available. In such cases the distance may be found by "Buckner's method," provided the horizon is in sight above the ship. This method was more especially designed for use on board ship, but it is equally available on shore. Every fort should have its own "horizon" table calculated and hung up, the difference being due to the varying height.

If there are two forts sufficiently far apart to allow of the distance between them forming a base of sufficient length, and telegraphic communication is established between the forts, then a chart of the approach, divided into small squares, will show with great accuracy the exact position of the enemy's ship; it will be at the intersection of two rulers, one of which is controlled by a telescope pointing at the ship from one fort, and the other ruler at the same fort is, by electricity, constrained to follow exactly and be parallel to the direction of the telescope at the other fort, also kept pointing at the enemy. This method may be usefully employed for torpedo purposes, as well as for gunnery.

In the absence of such an arrangement, the bearing of the ship, and the changes in it, may be telegraphed from one fort to the other and plotted on a chart. The distance may also be found by the dip angle, observed with a theodolite.

Buckner's Table for Finding the Distance of an Object at Sea.

To use the table, let an observer from the cross-trees measure the angle between the distant horizon and the enemy's water-line, and look into the table with that angle; opposite to it, in the column marked distances, will be found the distance of the object in yards

YARDS.	HEIGHT OF THE EYE ABOVE THE LEVEL OF THE SEA, IN FEET.								
Distance.	20	30	40	50	60	70	80	90	100
	° '	° '	° '	° '	° '	° '	° '	° '	° '
100........	3 44	5 37	7 29	9 21	11 11	13 00	14 47	16 34	18 16
200........	1 50	2 46	3 43	4 39	5 35	6 31	7 27	8 23	9 18
300........	1 12	1 49	2 26	3 04	3 41	4 19	4 56	5 33	6 11
400........	52	1 21	1 46	2 16	2 44	3 12	3 40	4 08	4 36
500........	41	1 03	1 25	1 48	2 10	2 32	2 54	3 17	3 39
600........	34	52	1 10	1 29	1 47	2 05	2 24	2 42	3 01
700........	28	44	1 01	1 15	1 31	1 46	2 01	2 18	2 34
800........	24	38	51	1 05	1 18	1 32	1 46	2 00	2 13
900........	21	33	45	57	1 00	1 22	1 33	1 45	1 57
1,000........	18	29	40	50	1 01	1 12	1 23	1 34	1 45
1,100........	16	26	35	45	55	1 05	1 15	1 24	1 34
1,200........	15	23	32	41	50	59	1 08	1 17	1 26
1,300........	13	21	29	37	45	53	1 02	1 10	1 18
1,400........	12	19	27	34	41	49	57	1 04	1 12
1,500........	11	18	24	31	38	45	52	59	1 07
1,600........	10	16	22	29	35	42	48	55	1 02
1,700........	09	15	21	27	33	39	45	51	58
1,800........	08	14	19	25	31	36	42	47	54
1,900........	08	13	18	23	29	34	39	45	50
2,000........	07	12	17	22	27	32	37	42	47
2,100........	06	11	16	20	25	30	35	40	45
2,200........	06	10	15	19	24	28	33	38	42
2,300........	05	10	14	18	22	27	31	36	40
2,400........	05	09	13	17	21	25	29	34	38
2,500........	05	08	12	16	20	24	28	32	36

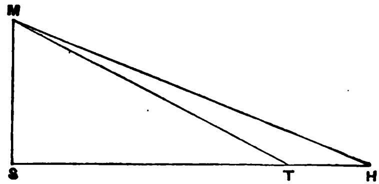
No correct use of this table can be made when the proximity of land may interfere with the distance of the horizon.

Table showing the Distance of the Horizon at Different Elevations.

Height.	Distance of the horizon.	Height.	Distance of the horizon.	Height.	Distance of the horizon.	Height.	Distance of the horizon.	Height.	Distance of the horizon.
Feet	Nautical miles.	Feet	Nautical miles.	Feet.	Nautical miles.	Feet.	Nautical miles.	Feet.	Nautical miles.
1	1.15	33	6.60	85	10.59	245	17.98	450	24.36
2	1.62	34	6.70	90	10.90	250	18.16	460	24.63
3	1.99	35	6.80	95	11.19	255	18.34	470	24.90
4	2.30	36	6.89	100	11.49	260	18.52	480	25.16
5	2.57	37	6.99	105	11.77	265	18.70	490	25.42
6	2.81	38	7.08	110	12.05	270	18.87	500	25.68
7	3.04	39	7.17	115	12.32	275	19.05	510	25.94
8	3.25	40	7.26	120	12.58	280	19.22	520	26.19
9	3.45	41	7.35	125	12.84	285	19.39	530	26.44
10	3.63	42	7.44	130	13.10	290	19.56	540	26.69
11	3.81	43	7.53	135	13.35	295	19.73	550	26.93
12	3.98	44	7.62	140	13.61	300	19.89	560	27.18
13	4.14	45	7.70	145	13.83	305	20.06	570	27.42
14	4.30	46	7.79	150	14.06	310	20.22	580	27.66
15	4.45	47	7.87	155	14.30	315	20.38	590	27.90
16	4.59	48	7.96	160	14.53	320	20.55	600	28.13
17	4.74	49	8.04	165	14.75	325	20.71	610	28.37
18	4.87	50	8.12	170	14.97	330	20.85	620	28.60
19	5.01	51	8.20	175	15.19	335	21.02	630	28.83
20	5.14	52	8.29	180	15.41	340	21.18	640	29.06
21	5.26	53	8.36	185	15.62	345	21.33	650	29.28
22	5.39	54	8.44	190	15.83	350	21.49	660	29.51
23	5.51	55	8.52	195	16.04	355	21.64	670	29.73
24	5.63	56	8.60	200	16.24	360	21.79	680	29.95
25	5.74	57	8.67	205	16.44	370	22.09	690	30.17
26	5.86	58	8.75	210	16.64	380	22.39	700	30.39
27	5.97	59	8.82	215	16.84	390	22.68	710	30.60
28	6.08	60	8.90	220	17.03	400	22.97	720	30.82
29	6.19	65	9.26	225	17.20	410	23.26	730	31.03
30	6.29	70	9.61	230	17.42	420	23.54	740	31.24
31	6.40	75	9.95	235	17.61	430	23.82	750	31.45
32	6.50	80	10.27	240	17.79	440	24.09	760	31.66

Approximately, correction for curvature in feet $= \frac{2D^2}{3}$, D being *the distance in statute* miles.

Finding Distance of a Target at Sea.



Example.—M S=height of main-top.
T M H, observed angle between the target and the horizon.
S H M = dip.
S T M = dip × observed angle.

THE DISTANCE A VESSEL IS OFF when seen from the masthead of another vessel, may be roughly calculated by using the *table showing the distance of the horizon at different elevations* in the following manner: Suppose height of observer's masthead to be 150 feet. A sail is seen from it, with half her top-sails visible above the horizon. An estimate must be formed of the height of half her top-sails—say 70 feet.

Height of 70 feet makes the horizon at that height as 9½ miles distant; and of 150 feet (height of observer's masthead), 14 miles; total distance between the two vessels, 23½ miles.

To Find the Distance from a Ship.

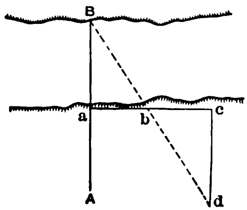
To the log. of the height of the masthead of the distant ship, add the log. cotangent of the observed masthead angle.

To Find the Distance of a Ship to Windward or to Leeward.

To the log. of the distance between the two ships, add the log. sine of the angle between a line at right angles to the wind and the bearing of the ship.

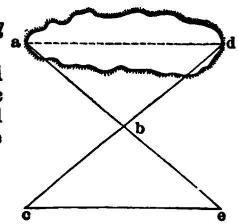
Measuring Distances on Shore.

To continue the measurement of the base line A B, *or to measure the distance across an intervening river, etc.*



Set off two equal lengths in the same straight line at any convenient angle from a to b and from b to c marking b and c with stakes; measure from c, on a line parallel to A B, the distance, c d, between c and a point d, where the stake a b came in line with the object B. The length, c d, will be equal to the required distance a B.

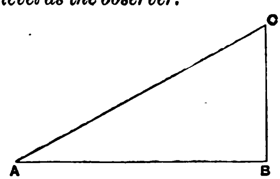
To measure the distance a d *across a small lake or marsh.*



Measure a straight line from a to e, and also from d to c, making e b = b a, and b c = b d, then, by equal triangles, e c is equal to a d, whence by measuring e c we get the required distance.

MEASURING HEIGHTS.

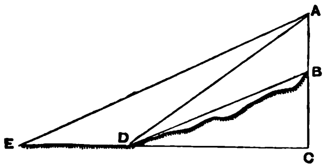
To find the height of an object, C B, *the base of which is accessible, and on the same level as the observer.*



Measure the angle B A C, and distance A B, and then:

$$C\,B = \tan.\,B\,A\,C \times A\,B.$$

To find the height of an inaccessible tower, A B, *and the difference of level between* B *and* D, *the nearest accessible point to* B A.



Erect a stake the height of the eye at D, and at E, on the same level as D, observe the angles of elevation A E C and A D C, and measure the base E D :

$$AC=\frac{E\,D}{\text{cotan. } A\,E\,D-\text{cotan. } A\,D\,C.}$$

The height B C can be ascertained in the same way, which subtracted from A C gives A B.

To find the height, from the angle of elevation or depression to an object, the distance being known.

$$\text{Height}=\frac{\text{Minutes and decimals in angle} \times \text{fathoms in distance.}}{}$$

(*Roughly.*)—If the object be accessible, measure the length of its shadow, and at the same time the shadow of a pole of known length (or your own shadow); the lengths of the shadows are proportional to the heights. This must be done quickly, as the sun is always on the move.

Or, recede from an artificial horizon until the reflected image of the summit is seen in the mercury. Measure the distances between this position and the artificial horizon, also between the artificial horizon and the foot of the object. The distances are in proportion to the height of the observer's eye and the height of the object.

Dip of the Horizon.

Approximately, the dip in minutes is the square root of the height in feet.

Height.	Dip.	Height.	Dip	Height.	Dip.
Feet.	′ ″	Feet.	′ ″	Feet.	′ ″
1	0 58	13	3 27	25	4 52
2	1 21	14	3 36	28	5 5
3	1 40	15	3 42	30	5 15
4	1 56	16	3 50	35	5 39
5	2 9	17	3 57	40	6 4
6	2 21	18	4 4	45	6 27
7	2 33	19	4 11	50	6 46
8	2 44	20	4 17	60	7 25
9	2 53	21	4 23	70	8 1
10	3 2	22	4 30	80	8 34
11	3 10	23	4 36	90	9 6
12	3 19	24	4 42	100	9 35

To find the height when the distance is known: To the constant log. 3.7840, add the log. of the distance in miles and the log. tan. of the corrected altitude. The nat. number of the sum of these logs. being added to the number from the following table, will give the height in feet:

Miles.	Feet.	Miles.	Feet.	Miles.	Feet.	Miles.	Feet.	Miles.	Feet.	Miles.	Feet.
1	0.9	11	107	21	390	31	850	41	1,487	55	2,677
2	3.5	12	127	22	428	32	906	42	1,561	60	3,186
3	8.0	13	149	23	468	33	964	43	1,636	65	3,740
4	14.1	14	173	24	510	34	1,023	44	1,713	70	4,337
5	22.1	15	199	25	553	35	1,084	45	1,792	75	4,976
6	31.8	16	226	26	598	36	1,147	46	1,872	80	5,675
7	43.3	16	256	27	645	37	1,211	47	1,954	85	6,394
8	56.6	17	287	28	694	38	1,278	48	2,039	90	7,172
9	71.6	19	319	29	745	39	1,346	49	3.124	95	7,987
10	88.4	20	354	30	797	40	1,416	50	2,212	100	8,852

The table is to be entered, with distance of the observer, in miles.

Example.—The altitude of a summit is (corrected for dip) 2° 48′, the distance 20 miles, the height of the eye 16 feet.

20 log	1.3010	Height above level of observer.	5,949
Const.	3.7840	Cor. for curvature at 20 miles.	354
Log. tan	8.6894	Height of observer's eye	16
5,949 ......log.	3.7744	Height required in feet	6,319

Table for Converting Knots into Statute Miles.

(*The knot*=6,080 *feet; the statute mile*=5,280 *feet.*)

Admiralty knots.	Statute miles.	Admiralty knots.	Statute miles.	Admiralty knots.	Statute miles.	Admiralty knots.	Statute miles.
1.00	1.151	7.25	8.348	13.50	15.545	19.75	22.742
1.25	1.439	7.50	8.636	13.75	15.833	20.00	23.030
1.50	1.729	7.75	8.924	14.00	16.121	20.25	23.318
1.75	2.015	8.00	9.212	14.25	16.409	20.50	23.606
2.00	2.303	8.25	9.500	14.50	16.696	20.75	23.893
2.25	2.590	8.50	9.787	14.75	16.984	21.00	24.181
2.50	2.878	8.75	10.075	15 00	17.272	21.25	24.469
2.75	3.166	9.00	10.363	15.25	17.560	21.50	24.757
3.00	3 454	9.25	10.615	15.50	17.848	21.75	25.045
3.25	3.742	9.50	10.939	15.75	18.136	22.00	25.333
3.50	4.030	9.75	11.237	16.00	18.424	22.25	25.621
3.75	4.318	10.00	11.515	16.25	18.712	22.50	25.909
4.00	4.606	10.25	11.803	16.50	18.999	22.75	26.196
4.25	4.893	10.50	12.090	16.75	19 287	23.00	26.484
4.50	5.181	10.75	12.378	17.00	19.575	23.25	26.772
4.75	5.469	11.00	12.666	17.25	19.863	23.50	27.060
5.00	5.757	11.25	12.954	17.50	20.151	23.75	27.348
5.25	6.045	11.50	13.242	17.75	20.439	24.00	27.636
5.50	6.333	11.75	13.530	18.00	20.727	24.25	27.924
5.75	6.621	12.00	13.818	18.25	21.015	24.50	28.212
6.00	6.909	12.25	14.106	18.50	21.303	24.75	28.499
6.25	7.196	12.50	14.393	18.75	21.590	25.00	28.787
6.50	7.484	12.75	14 681	19.00	21.878	——	——
6.75	7.772	13.00	14.969	19.25	22 166	——	——
7.00	8.060	13.25	15.257	19.50	22.454	——	——

The geographical mile is generally defined to be the length of a minute of arc in the earth's equator; but the nautical mile, as defined by hydrographers, is the length of a minute of the meridian, and is different for every different latitude. It is equal to a minute of arc in a *circle, whose radius* is the radius of the curvature of the meridian at *the latitude of the place.*

Measuring Heights by Barometer.

In this table, the difference between the number of feet opposite the height of a barometer at one station and that at another is the approximate difference in the height of the stations.

Barometer in inches.	Height in feet.	Barometer in inches.	Height in feet.	Barometer in inches.	Height in feet.	Barometer in inches.	Height in feet.
31.0	0	27.9	2,769	24.8	5,869	21.7	9,388
30.9	85	27.8	2,864	24.7	5,976	21.6	9,510
30.8	170	27.7	2,959	24.6	6,083	21.5	9,632
30.7	255	27.6	3,054	24.5	6,190	21.4	9.755
30.6	341	27.5	3,149	24.4	6,207	21.3	9,878
30.5	427	27.4	3,245	24.3	6.405	21.2	10.002
30.4	513	27.3	3,341	24.2	6,514	21.1	10,127
30.3	600	27.2	3,438	24.1	6,623	21.0	10,253
30.2	687	27.1	3.535	24.0	6,733	20.9	10.379
30.1	774	27.0	3,633	23.9	6,843	20.8	10.506
30.0	862	26.9	3,731	23.8	6,953	20.7	10.633
29.9	950	26 8	3,829	23.7	7,064	20.6	10,760
29.8	1,038	26 7	3,927	23.6	7,175	20.5	10,889
29.7	1,126	26.6	4,025	23.5	7,287	20.4	11,018
29.6	1,215	26.5	4,124	23.4	7.399	20.3	11,148
29.5	1,304	26.4	4,223	23.3	7,512	20.2	11,278
29.4	1,393	26.3	4,323	23.2	7.625	20.1	11,409
29.3	1,482	26.2	4,423	23.1	7,729	20.0	11,541
29.2	1,572	26.1	4,524	23.0	7,854	19.9	11,673
29.1	1,662	26.0	4,625	22.9	7,969	19.8	11,805
29.0	1,753	25.9	4,726	22.8	8,085	19.7	11,939
28.9	1,844	25.8	4,828	22.7	8,201	19.6	12.074
28.8	1,935	25.7	4,930	22.6	8,317	19.5	12,210
28.7	2,027	25.6	5,033	22.5	8,434	19.4	12,346
28.6	2,119	25.5	5,136	22.4	8,551	19.3	12,483
28.5	2,211	25.4	5,240	22.3	8,669	19.2	12,620
28.4	2,303	25 3	5,344	22.2	8.787	19.1	12.757
28.3	2,396	25.2	5.448	22.1	8,906	19.0	12,894
28.2	2,489	25.1	5,553	22.0	9,025	18.9	12,948
28 1	2,582	25.0	5,658	21.9	9,145	18.8	13,080
28.0	2,675	24.9	5,763	21.8	9,266	18.7	13,219

If possible, simultaneous observations, by signal or time, of two barometers previously compared at the same station, should be taken. But little dependence can be placed on observations beyond four thousand feet when made with the aneroid.

TIMES OF CERTAIN PHENOMENA.

To Find the Time to Fire the Daylight Gun.

DAYBREAK, or the commencing of morning twilight, occurs after the sun has crossed the crepusculum, or twilight circle, which is 18° below the horizon.

RULE.—Under the latitude put the declination, marking them with their proper names, N. or S. If the names are alike, take the difference; if unlike, take the sum and under this put the constant angle 108°, take the sum and difference. Add together the log. sec. of the two first terms (rejecting tens in the index), and half log. hav. of the two last. With the sum as a log. hav., take out the corresponding angle in time at the top of the page, which will be the ending of evening twilight, and which, subtracted from twelve hours, will give the beginning of morning twilight, or daylight, in *apparent time.*

	° ′	
Latitude	22 17 N.	Log. sec. 0.0337
Declination......	15 03 N.	Log. sec. 0.0151
	7 14	
	108 00	
	115 14	½ Log. hav. 4.9266
	100 46	½ Log. hav. 4.8867
	H. M.	Log. hav. 9.8621
Evening twilight ends	7 49	
	12 00	
	4 11 Morning twilight begins.	

To Find the Time of Sunrise or Sunset.—Add together the log. tang. of latitude and declination. The result will be the log. cos. of an angle in time which, if the latitude and declination are *unlike*, will be the apparent time of sunset, and, subtracted from twelve hours, the *apparent time* of sunrise.

If the latitude and declination are *alike*, the angle first found will be the apparent time of sunrise and, subtracted from twelve hours, the apparent time to sunset. If mean time (harbor time) is required, the equation of time must be applied after the time of sunset and sunrise has been determined.

Example:

	° ′	
Latitude..............	22 17 N.	Tang. 9.6126
Declination	15 3 N.	Tang. 9.4296
	H. M.	
	5 35	Cos. 9.0422
	12 00	
Apparent time.........	6 25	
Equation of time.......	03	
Mean time sunset......	6 22	

This is the time of the setting of the sun's *centre*, to the eye, at the level of the sea, and without the atmosphere.

To find the change in the time of *apparent* rising or setting, due to the horizontal refraction and the height of the spectator, add together the log. sec. of the latitude and declination, the log. cosec. of the hour angle at rising or setting, and the log. sine of 34′ + dip for the height of the eye; the sum is the log. sine of the portion of time required, nearly.

Example.—Lat. 28° 16′ N., declination, 16° 10′ N.: required the difference in the times of sunset to the eye at the level of the sea, and elevated 16 feet above it.

Hour angle at setting, 6 h. 36 m.

Latitude	sec.	0.0551
Declination....................	sec.	0.0175
Hour angle.....................	cosec.	0.0054
34′+4′.........................	sin.	8.0435
		8.1215

Time required, 3 m. 2 s.

Sunset Table.—For constructing a sunset table for harbor use, the time of setting of the sun's *upper* limb in the *visible* horizon, considering the eye to be *at the level of the sea*, is what is required.

To obtain this, add together the log. sec. of the latitude and declination, the log. cosec. of the hour angle at rising or setting, and the log. sine of 34′+semi-diameter of sun; the sum is the log. sine of the portion of time to be added to the mean time of setting of the sun's centre, to obtain the mean time of the disappearance of the upper limb.

If Raper's "Navigation" is at hand, the apparent time of setting of the sun's centre may be taken from table 26; by applying the equation of time the mean time is obtained, and the above correction is then to be added to get the mean time of setting of the sun's upper limb.

FINDING THE STARS.

THE most conspicuous stars have been designated by names, and the stars in each constellation are distinguished, for reference, by letters and numbers. The letters used for this purpose are the small letters of the Greek alphabet.

In finding any star in the heavens, it is customary to refer to some one star or constellation as known: the Great Bear, called also by the Latin name *Ursa Major*, in the northern part of the heavens, and consisting of seven principal stars, is the most convenient for the purpose.

The two stars α and β point nearly to POLARIS (or the Pole Star), and are hence called the *Pointers*.

A line from Polaris through η (the last of the tail) passes at 31° beyond η, through *Arcturus*, a very bright star.

A line from Polaris perpendicular to the line of the Pointers and on the opposite side to the Great Bear, passes at 48° distance through *Capella*, one of the brightest stars.

In the same line, about the same distance on the opposite side of the Pole, is α *Lyræ*, called also VEGA and *Lyra*, a large white star in the HARP.

At one-third of the distance from *Arcturus* to α *Lyræ* is ALPHACCA, the brightest star of a semicircular group called the NORTHERN CROWN.

About 23° to the eastward of α *Lyræ*, and about the same distance as this star is from Polaris, is μ *Cygni*, the bright star in the *Swan*.

A line from Polaris passing between this last and α *Lyræ*, and produced to an equal distance beyond them, passes through α *Aquilæ* (or ALTAIR), a bright star between two small ones.

A line from Polaris drawn between *Capella* and a star close to the eastward of it, passes to the westward of the constellation ORION.

The two northern stars of the four at the corners are the shoulders, the northernmost of which is α *Orionis*.

The brightest of the two southern stars, the feet, is called *Rigel*. In the middle are three stars forming the belt, the northernmost of which is nearly on the equator.

About 25° to the northwestward of the belt, and not far out of its line, is *Aldebaran*, which may be known by its red color.

A line from Aldebaran through the belt passes at about 20° on the other side through *Sirius*, the brightest star in the heavens.

Sirius, the eastern shoulder, and *Procyon* (to the eastward of Orion and northward of Sirius) form an equilateral triangle.

Midway between the Great Bear and Orion are the *Twins*, CASTOR and POLLUX (the latter the southern and brightest), about 4° apart. The line from Polaris to Procyon passes between them.

A line from Rigel through Procyon passes at an equal distance beyond to the northward of *Regulus*.

A line from Polaris through ζ Ursa Majoris passes at 70° distance through *Spica Virginis*.

A line from Regulus through *Spica* passes at 45° distance through *Antares*, a bright reddish star.

The line from the Pointers carried through the Pole to about 75° beyond it, passes through MARCAB (α *Pegasi*).

A line from Polaris through *Marcab* passes at 45° distance through *Fomalhaut*, a very bright star.

Achernar, *Fomalhaut*, and *Canopus* are in a line and nearly equidistant, being about 40° apart.

The SOUTHERN CROSS is about as far from the South Pole as the Great Bear is from the North Pole—γ is the head and α the foot.

When some stars are known, the rest are easily found by the times of their meridian passages and their declinations. A star may also

be identified by means of its altitude or azimuth, computed approximately.

SHAPING THE COURSE.

BEFORE the shelter of a port is quitted, whether able to choose the time for sailing or obliged to start at a predetermined hour, due regard should be paid to the wind and weather, tide and current, that may be experienced on leaving the harbor.

When clear of land, and having a sufficient offing, the course to be shaped is again subject to the various considerations of wind and weather, together with those of the shortest distance, the safest track, and the greatest speed.

In high latitudes such a consideration should always be kept in view, while deciding on which tack to lay the ship.

GREAT CIRCLE SAILING.

GREAT CIRCLE SAILING being now much used by steamers and sailing vessels frequenting high latitudes, a ready way of finding the course and distance along such an arc—accurate within sufficient limits—is useful to navigators, when elaborate rules are not immediately available.

It should be remembered that land, ice, weather, currents, or other causes, considerably limit the adoption of great circle sailing; and that along or nearly along a meridian, as well as within a few degrees of the equator, all straight lines on Mercator's chart nearly represent arcs of great circles.

Mixed or composite courses may generally be drawn by eye after tracing a great circle arc.

The best method that has yet been devised for sweeping an arc of a great circle on one side of the equator (on Mercator's chart) is embodied in the following:

Rules.

1.—"Join the first and last points of the course (or the point of departure and point of arrival) by a straight line; find its middle; erect there *a perpendicular to* that line on the side next the equa-

or, and produce it, if necessary, beyond the equator. The centre of the sweep will be on this perpendicular.

2.—" With the middle latitude (between the two places) enter the following table, and take out the corresponding parallel :

Middle Latitude. °		Corresponding Parallel. °	′
20	Opposite name to lat. of points.	81	13
22		78	16
24		74	59
26		71	26
28		67	38
30		63	37
32		59	25
34		55	5
36		50	36
38		46	0
40		41	18
42		36	31
44		31	38
46		26	42
48		21	42
50		16	39
52		11	33
54		6	24
56		1	13
58	Same name as lat. of points.	4	0
60		9	15
62		14	32
64		19	50
66		25	9
68		30	30
70		35	52
72		41	14
74		46	37
76		52	1
78		57	25
80		62	51

3.—"The centre of the sweep will be the intersection of the perpendicular with the parallel thus found.

4.—"Fix one point of the compasses in this intersection, and with the other point sweep through the point of departure and point of arrival; this sweep is the curve required."*

The above method, by G. B. AIRY, Esq., Astronomer Royal, approaches nearly to the correct projection of a great circle.

For a long voyage, the arc of a great circle should be traced on the chart as a guide to be closely followed, circumstances permitting.

When driven, or otherwise separated a considerable distance from an intended track on the chart, a new course, or arc, should be traced, and no attempt made to regain the first one.

Mercator Course (Rhumb Line) and Great Circle Course.

On a Mercator chart, the course between any two places is a straight line. The course between St. John's, Newfoundland, and the Scilly Islands (English Channel) is N. 85¾° E., or E. ½ N. (easterly), and the distance is 1,847 miles; but this rhumb line (and indeed any course on Mercator's projection, except a *true* north, south, east, or west one) when placed on a globe, cutting every meridian it passes at the same angle, is a spiral, which, if pursued, and no land intervened, would be always tending polar-wise, without reaching the pole. The *arc of a great circle* is the *true course* between two places, and the distance along that track is the shortest possible; it does not seem to be such when drawn on a Mercator's chart, but it is so, nevertheless. The great circle course between St. John's and the Scilly Islands is represented on the chart as a curve. A ship on such a course would be constantly changing the direction of her head, as every meridian is not cut at the same angle; in this case, at starting the course would be N. 68° E., or E.N.E., gradually change towards east, as the highest latitude (latitude of vertex), 51° 14′ N., in long. 24° 10′ W., was reached; the direction would then tend to southward of east, and the last course would be, S. 76½° E., or E. by S. southerly. The distance is 1,807 miles by the great circle.

It is always useful to know the position of the great circle with

* *Monthly Notices of the Royal* Astronomical Society, vol. xviii., p. 131.

respect to the Mercator track, because when winds head a vessel, that tack must be best which leads the nearest to the great circle. On the great circle, a ship's head always points directly to her port; on the Mercator track she only appears to point to it, although on the given course she must eventually reach the port.

LATITUDE AND LONGITUDE METHODS.

Latitude by Meridian Observations.

OF all observations the meridian altitude gives the most certain and trustworthy result, for it is easy to observe, quickly worked out, and quite independent of any other observation, besides furnishing what is necessary to be known before other observations for longitude or compass error can be worked up.

OBSERVATION.—Commence some time before noon, and take the altitude of the sun's lower limb. After waiting two or three minutes, upon looking again, the sun will be found to have risen a little; the amount which it has risen will give you some idea of the time from noon, for if close upon noon the rise will be hardly perceptible. Bring the sun down to the horizon again, and as the time approaches 12 o'clock, according to your judgment, continue to bring the sun down at short intervals by a touch of the tangent screw, until the sun no longer rises, but, on the contrary, sensibly *dips*. Keep the highest altitude observed and read off.

If the sun is likely to be obscured at 12 o'clock, although clear at half-past 11, note the time by your watch when each altitude is taken, and read off. Should the meridian altitude not be obtained, the last altitude observed before the sun was obscured would be useful, either for a reduction to the meridian, or, in conjunction with a morning or afternoon sight, for a double altitude.

THE COMPUTATION.—The latitude is measured by an arc of the meridian contained between the zenith and the equator; therefore, if the distance from the zenith when on the meridian and the declination be obtained, the latitude is easily found.

To get the sun's true central altitude, the semi-diameter is to be added if the lower limb is observed, or subtracted if the upper limb is observed.

The dip and refraction are to be subtracted, and the parallax to *be added.*

This altitude being subtracted from 90° will give the true zenith distance.

The declination is next found from the *Nautical Almanac*, and corrected for the longitude.

The correction for the longitude, it must be remembered, is to be added in west longitude when the declination is increasing, and subtracted when decreasing; and vice versa in east longitude.

Having the meridian zenith distance and declination, the latitude is to be found as follows:

If the object bear south when on the meridian, call the zenith distance *north;* but if the bearing be north, call the zenith distance *south.* If the zenith distance and declination are of the same name, add them, but if they are of different names, take their difference; the result will be the latitude, which will be of the same name as the greater.

Example.—February 26, 1878. Longitude about 60° W.

	° ′		° ′
Altitude (lower limb)...	39 43 S.	Dec.........	8 39 S.
Correction	11	Corr	4
True alt................	39 94	True dec...	0 35 S.
	90 00		
Zenith dist.............	50 06 N.	Diff. names subtract.	
Declination	8 35 S.		
Latitude	41 31 N.	Name of greater.	

Short Method.—It appears to be a common practice at sea to perform the greater portion of the calculation before going on deck, working out what is known as a "constant," which is noted on a slip of paper, and the latitude is obtained at once by subtracting the observed altitude from the "constant."

The formula may be stated as follows:

Let L = the latitude.
" d = the true declination.
" a = true *central altitude* of the sun.

Let a′ = observed altitude of sun's lower limb.
" c = correction to observed altitude to reduce it to true central altitude.

Then, when the latitude and declination are of the same name:

$$L = 90° - a' + d, \text{ and as } a = (a' + c)$$
$$L = 90° - (a' + c) + d, \text{ or}$$
$$L = (90° + d - c) - a'. \quad (1.)$$

When the latitude and declination are of different names:

$$L = 90° - a - d; \text{ or, as before,}$$
$$L = 90° - (a' + c) - d, \text{ and also}$$
$$L = (90° - d - c) - a'. \quad (2.)$$

The portion within the parentheses may be computed before the observation, and all that remains to be done, in either case, is to subtract the observed altitude.

As considerable time may be wasted by the usual mode of commencing the observation nearly half an hour before noon, it is well to find from A.M. observations for time, and by allowing for the run of the ship in the interval, the time of apparent noon by a watch, and to begin observing the altitude within three or four minutes of that time.

When the sea is heavy, it is recommended to observe three or four altitudes in quick succession, close to the meridian altitude.

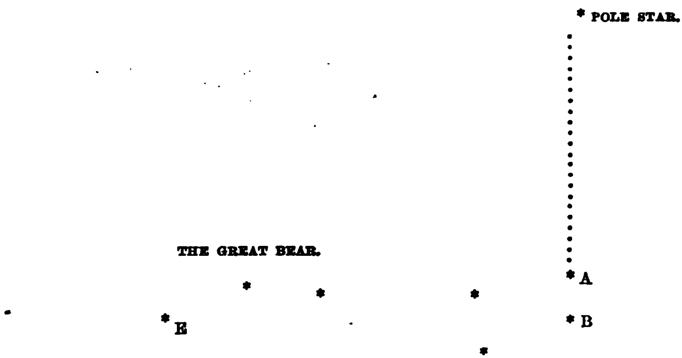
If the observer is changing his latitude, and the sun its declination, the *maximum* altitude is not at the instant of meridian passage, but *before*, if the body and zenith are separating; *after*, if they are approaching.

Such a correction, however, is of little practical importance at sea, and may be neglected.

To find the Latitude by the Pole Star.

The attention of seamen is particularly directed to the great advantage of determining their latitude by the altitude of stars during that portion of twilight in which both they and the horizon are to be seen with distinctiveness. People too often wait till it is so dark that the line of the horizon becomes indistinct; whereas the true time to take the Pole Star, or any other of which the time of meridian passage suits, is after the sun has set, or before he rises.

In finding any star in the heavens, it is necessary to refer to some one star, or group of stars (called a constellation), as known. The Great Bear, called also by the name *Ursæ Majoris*, a constellation of the figure shown below, in the northern part of the heavens, and consisting of seven principal stars, is most convenient for finding the Pole Star, as also most of the stars in the northern hemisphere.



To Find the Pole Star.

Draw a line from B to A of the Great Bear, and produce it about the length of the whole constellation of the Great Bear; this line will terminate near the Pole Star. Since it is one of the most conspicuous in that part of the heavens, it will be easily found in this manner. The stars, A and B, Ursæ Majoris (Great Bear), used for finding the Pole Star, are for this reason called the *Pointers*.

TAKING THE OBSERVATION.—Bring the index nearly to 0 on the arc, holding the instrument vertically, and direct the view to the star through the transparent part of the horizon glass. Move the index slowly by the hand, and watch in the quicksilvered part for the motion *of the image of the* star, which then bring down and

follow slowly to the horizon, taking care not to lose sight of the image till a contact is made with the nearest point of the horizon.

Note the time of observation.

THE COMPUTATION.—Correct the observed altitude for index error, dip, and refraction.

Reduce the recorded time of observation to local sidereal time.

If the sidereal time is less than 1 h. 16 m., subtract it from 1 h. 16 m.; between 1 h. 16 m. and 13 h. 16 m., subtract 1 h. 16 m. from it; greater than 13 h. 16 m., subtract it from 25 h. 16 m.; and the remainder is the *hour angle* of Polaris.

Enter the table with this hour angle, take out the corresponding correction, and apply it to the true altitude according to its sign. The result is the latitude of the place.

The correction if the time be found on			The correction if the time be found on		
This side is *subtractive*.	Correction.	This side is *additive*.	This side is *subtractive*.	Correction.	This side is *additive*.
H. M.	° ′	H. M.	H. M.	° ′	H. M.
0 05	1 19	11 55	3 05	0 54	8 55
15	19	45	15	51	45
25	18	35	25	48	35
35	18	25	35	46	25
45	17	15	45	43	15
55	16	05	55	40	05
1 05	1 16	10 55	4 05	0 37	7 55
15	14	45	15	34	45
25	13	35	25	31	35
35	12	25	35	27	25
45	10	15	45	24	15
55	09	05	55	21	05
2 05	1 07	9 55	5 05	0 18	6 55
15	05	45	15	14	45
25	03	35	25	11	35
35	01	25	35	07	25
45	0 59	15	45	04	15
55	57	05	55	01	05
			6 00	0	00

Longitude by Single Altitude of the Sun (or "Time Sight").

Observe in quick succession three or five altitudes of the sun, when rising or falling fastest, or when bearing nearly E. or W., and note the time of each by the chronometer, or by a watch compared with it.

Take the mean of the noted times, and from it find the Greenwich mean time; for which take from the *Almanac* the declination, equation of time, and semi-diameter of the sun.

Take the mean of the readings of the instrument, and to it add the semi-diameter (if the lower limb has been observed, otherwise subtract it) and parallax, and subtract the dip and refraction to obtain the sun's true central altitude.

The ship's latitude must be found for the time of observation by carrying the reckoning forward to that time. Then if the latitude and declination be both north or both south, subtract the declination from 90° to obtain the polar distance; but if the latitude and declination have different names, add the declination to 90° to get the polar distance.

Add together the altitude, the latitude, and polar distance; from the half sum subtract the altitude and note the remainder.

Then add together the log. secant of the latitude, the log. cosecant of the polar distance, the log. cosine of the half sum, and the log sine of the remainder; half the sum of these four logarithms being found in the column log. sines (Table XXVII., Bowd.) will correspond to the hour angle, or local apparent time, in one of the hour columns.

Apply the equation of time to obtain the local mean time, and this, subtracted from the Greenwich mean time, will give the longitude in time, which should then be turned into arc.

When the declination and latitude are nearly the same, the sun is nearest the prime vertical but a short time before and after its meridian passage, so that a very great altitude may be used.

It is recommended not to use altitudes of less than 10°, on account of the uncertainty of the refraction.

At sea it is customary to reduce longitudes obtained from day observations to noon, by allowing for the run of the ship in the interval, and for known currents.

Those *from night observations* are recorded for the time of observation.

Longitude from Equal Altitudes at Sea.

When the sun's meridian altitude is over 70°, the longitude of the ship may be determined at the same time as the latitude, with sufficient accuracy for the ordinary purposes of navigation, by observing the times at equal altitudes of the sun, about five or six minutes before and after noon. The sum of these times divided by 2, and corrected by the equation of time *applied as to mean time,* will give the time of mean noon at ship as shown by the watch. Applying to this time the error of the watch on Greenwich, will give Greenwich time at the mean noon of the ship, which is the longitude in time.

Example.—On April 5, 1876, in lat. by account 1° 13′ S., lon. 84° 6′ W., the following times at equal altitude of the sun near noon were observed to determine the longitude:

	H.	M.	S.
Time A.M.	1	1	42
Time P.M.	1	12	00
2)	2	13	42
	1	6	51
Equation of time applied as to mean time	0	2	32
Watch time of ship mean noon......	1	4	19
Watch slow on Greenwich...........	4	33	36
Greenwich time at ship mean noon..	5	37	55=long. 84° 28′ 45′′

Approximate Longitude by Chronometer at Noon.

(*Somerscales.*)

Observe the sun's altitude about half an hour before noon note the corresponding time by chronometer. Then set the s to an altitude as much greater or less than the first altitude ship has made difference of latitude in the interval.

The method of applying is : add the difference of latitude *altitude when the* ship is approaching the sun, and subtract i *ship is receding* from the sun.

Having the index set to the new altitude, and as the time approaches the same hour-angle after noon that it was before noon when the first altitude was measured, watch for the contact, and the instant this takes place, note the time by chronometer again. The altitude is now of no further use. The chronometer times alone are required. Add the two times together, and divide by 2, to get the middle time, and apply the error; this gives the Greenwich mean time when the sun was on the meridian.

Apply the equation of time to the Greenwich mean time to obtain the Greenwich apparent time.

Under the Greenwich apparent time write down ship's apparent time (noon), and find the longitude as usual.

Example I.—On April 19, 1878, ship steering east true, the altitude of the sun *before* noon was 47° 0′ when the chronometer showed 3 h. 38 m. 45 s.; and again *after* noon the sun was at the same altitude when the chronometer showed 4 h. 42 m. 5 s. Chronometer fast 12 m. 52 s. Required the longitude at noon.

NOTE.—The course of the ship being due east in this case, the sun will be abeam at noon; and the ship neither approaching nor receding from the sun, no alteration in the altitude is made.

		H.	M.	S.
Chronometer times	{	3	38	45
		4	42	5
	2)	8	20	50
		4	10	25
Error			12	52
Greenwich mean time		3	57	33
Equation of time	+		0	57
Greenwich apparent time		3	58	30
Ship's apparent time (noon)		0	0	0
		3	58	30
				3
		11	55	30
				5
Longitude		59	37	30 W.

Example II.—May 24th, in the South Atlantic, ship steering S.E. by S. 9 knots; the altitude of the sun before noon was 64° 50′ when the Greenwich mean time was 11 h. 59 m. 34 s. (sun bearing north at noon). After an interval of 40 m., the sun was found to be approaching the same altitude again, and the index was set to an altitude of 64° 45′. The sun came down to this altitude when the Greenwich mean time was 0 h. 40 m. 40 s.

NOTE.—Run in 40 m.=6 miles; diff. lat. 5′ to subtract from the 1st altitude, because ship is sailing away from the sun.

	H.	M.	S.	
Greenwich times..........................	{ 11	59	34	A.M.
	12	40	40	
2)	24	40	14	
Greenwich mean time........................	12	20	7	
Equation of time........................	+	3	25	
Greenwich apparent time....................	12	23	32	
Ship's apparent time (noon).................	12	0	0	
	0	23	32	
			3	
	1	10	36	
			5	
Longitude............	5	53	0	W.

With respect to the amount of dependence which can be placed upon the longitude as found by the foregoing method, it may be stated as an instance in point, that in the first example an error of 1′ in the altitude to be set on the instrument (and an error of this amount might easily occur in estimating the difference of latitude made during the interval) would make about 4′ error in the longitude. This fact is sufficient to show the rough nature of the problem.

The same problem will sometimes be seen recommended to the navigator without any caution as to its uncertainty, and, what is worse, *without the correction to the altitude for the run of the ship.*

It need hardly be said that this omission renders the problem quite useless for any purpose whatever.

It would be a great mistake to confound the above problem with a problem which has a prominent place in all works on navigation, namely, the equal altitude problem. Although they both depend upon the same principle, they have quite different applications; and the real equal altitude requires conditions to be fulfilled (such as the ship not changing her position) which prevents its being used for the ordinary navigation of the ship.

Approximate Latitude and Longitude at Noon.

(*Somerscales.*)

An altitude is obtained at about half past eleven, with the corresponding time by chronometer. The sun passes the meridian (suppose while obscured) and approaches the same altitude again, and the index of the sextant is either advanced or put back the amount of the difference of latitude made during the interval. (Adding the difference of latitude to the altitude when the ship is approaching the sun, and subtracting when the ship is receding from the sun.) Having set the index to the new altitude, watch for the sun coming to this altitude, and note the time by chronometer again.

Now proceed as follows:

Subtract the first time from the second, and divide by 2. This gives the hour angle, or time from noon when each altitude is obtained.

Use either the first or second altitude, and the hour angle just found, to obtain the latitude by the reduction to the meridian. (If Towson's tables are at hand, the latitude may be found from them by inspection, almost.)

Proceed to get the longitude by the method of equal altitudes at sea.

Example.—October 17, 1878, in the N. Atlantic, the sun's altitude before noon was observed to be 22° 52′ when the chronometer showed 0 h. 29 m. 54 s. After running W.S.W. 9 miles, the sun was observed to be approaching the same altitude again, and the sextant was set to 22° 55′ (3′ being the difference of latitude made *towards* the sun). When the sun attained this altitude, the chronometer showed 1 h. 27 m. 26 s. Chronometer fast 2 m. 12 s. Height of eye 24 feet. *Required the latitude* and longitude.

LATITUDE BY TOWSON'S TABLES.

		H.	M.	S.	
Chronometer......		0	29	54	
		1	27	26	
		2)	57	32	
Hour angle........			28	46	
			°	′	
True declination...			9	20	S.
Augmentation				4	
Augmented decl....			9	24	S.
			°	′	
2d obs. altitude.....			22	55	S.
Correction..........	+			9	
True altitude.......			23	4	
Augmentation......				11	
			23	15	
			90		
Zenith distance......			66	45	N.
Declination.........			9	24	S.
Latitude..			57	21	N.

LONGITUDE BY CHRONOMETER.

		H.	M.	S.
Chronometer......		0	29	54
		1	27	26
	2)	1	57	20
		0	58	40
Error fast..........			2	12
Green'ch mean time		0	56	28
Equation of time...	+		14	36
Greenwich app. time		1	11	4
Ship's app. time....		0	0	0
		1	11	4
				3
		3	33	12
				5
Longitude..		17	46	0 W.

It will be observed that we have worked with the *second* altitude in finding the latitude, which is, therefore, strictly speaking, the latitude at 28 minutes past noon—the time when the altitude was taken.

The low altitude, and consequently slow rise of the sun near noon, would be very much against getting a good observation for *time* in the above case. The latitude will always be more correct than the longitude, and the longitude will be better in low than in high latitudes.

Longitude from Observations at Sunrise or Sunset.

It frequently happens that the sun is visible for a short time after rising or before setting, although obscured for the remainder of the day, thus affording the navigator an opportunity of obtaining the true time, from which he may ascertain the longitude.

The altitude taken from the following table, according to the height of the eye, corrected *inversely* for the index error, is to be placed upon the sextant; the observer should watch the rising or setting sun until the altitude is on, and then note the time by chronometer. The upper limb is to be preferred. If there are two observers, the second might at the same time take the lower limb:

Sun's semi-diameter.	Height of eye, 13 feet.		Height of eye, 21 feet.	
	Altitude of upper limb.	Altitude of lower limb.	Altitude of upper limb.	Altitude of lower limb.
′ ″	′ ″	′ ″	′ ″	′ ″
15 45	45 55	18 20	46 55	19 20
15 50	46 00	18 15	46 59	19 15
15 55	46 5	18 10	47 2	19 10
16 00	46 9	18 6	47 6	19 5
16 5	46 13	18 3	47 10	19 00
16 10	46 17	17 59	47 15	18 55
16 15	46 20	17 55	47 20	18 50

RULE.—To the log. tan. of the latitude, add the log. tan. of the sun's declination, and the sum, rejecting 10 from the index, will be the log. sin. of an arc, which take from the tables in time. If the latitude and declination are of the same name, add time to 6 hours at sunset, and subtract it at sunrise.

If the latitude and declination are of different names, add the time found to 6 hours at sunrise and subtract it at sunset.

To the time so found apply the equation of time, and the result will be ship's *mean time.*

Example.—August 31, 1880, in latitude 18° 43′ S., the sun set at 3 h. 21 m. 8 s. Greenwich mean time, required the longitude:

	° ′		
Declination............	8 45 N.	Log. tan....	9.1873
Latitude...............	18 43 S.	Log. tan....	9.5300
	H. M. S.	Log. sin....	8.7173
	0 11 58		
	6 00 00		
	5 48 02		
Equation of time........	19		
Local mean time.........	5 48 21		
Greenwich mean time....	3 21 08		
Longitude in time.......	2 27 13=30° 48′ 15″ E.		

N.B.—This method should be used only between the parallels of 40° N. and 40° S.

Another Method of Finding the Longitude at Sunset.

(*Somerscales.*)

This is to be considered as a makeshift rather than a legitimate method of finding the longitude. It has some advantages over the ordinary chronometer sight, but has the radical defect of being less trustworthy than the altitude on the prime vertical. When the altitude of the sun near the prime vertical can be obtained, no prudent navigator will neglect it for the sake of an approximate method. Under some circumstances, however, it may happen that an approximation to the position of the ship is all that is possible, and the choice is then between these observations and none at all.

Note the exact time by chronometer when the sun's lower limb *touches the horizon*, either at sunrise or sunset. A sextant telescope *with a suitable* screen may be used to observe with.

The observation is then worked out very much the same as an ordinary chronometer sight. The altitude (or rather the *depression*—for the refraction causes the sun to appear as setting when he is really below the horizon) is taken as a constant quantity in all cases, namely, 21°, and the only difference in the rule is to change the names of the last two logarithms, these are: *sine* of the half sum, and *cosine* of the remainder, instead of the usual cosine and sine. The following example will illustrate this:

August 16, 1878, ship in latitude 49° 10′ N., when making the English Channel the sun's lower limb touched the horizon, when setting, when the time by chronometer was 7 h. 36 m. 22 s. (slow 5 m. 0 s.). Required the longitude at sunset.

	H.	M.	S.
Chronometer	7	36	22
Slow		5	0
Greenwich mean time	7	41	42

	° ′		′		M. S.		s.
Decl.	13 43 N.	Diff.	47	Equ. T.	4 6	Diff.	.51
	6		8		4		8
True decl.	13 37		60) 376		4 2		4 08
Polar dist.	76 23		6-16		to add		

	° ′		
Depression	0 21		
Latitude	49 10	Sec.	10.1845
Polar distance	76 23	Cosec.	10.0124
	2) 125 54		
	62 57	Sin.	9.9497
Remainder	62 36	Cos.	9.6629
Ship's *apparent time, 7 h. 7 m. 25 s.*		Log.	0.8095

		H.	M.	S.
Ship's apparent time		7	7	25
Equation of time	+		4	2
Ship's mean time		7	11	27
Greenwich mean time		7	41	22
		0	29	55
				3
		1	29	45
				5
Longitude		7	28	45 W.

REMARKS ON SUMNER'S METHOD.

It is hardly too much to say that this is one of the most valuable methods ever discovered for determining a ship's position at sea; the computation required being merely a small extension of the every day work in navigation.

Sumner's method involves finding, by means of an observed altitude of a heavenly body and two assumed latitudes, two longitudes by chronometer, the line on the chart joining the two points so obtained, being called the *line of position.*

A second observed altitude, separated from the first by a suitable difference of bearing, gives by similar treatment another line of position, the intersection of which with the first line of position projected for the run of the ship in the interval (that is, moved parallel to itself along the course, and to the distance made good by the ship), determines the place of the ship at the second observation. The line of position can, however, be obtained from *one* assumed latitude if the true bearing of the sun or celestial object observed be known, for the direction of the line of position differs 90° from the direction or bearing of the object.

Burdwood's and Davis's tables of sun's true bearing or azimuth supply the true bearing of any celestial object whose declination does not exceed 23°. By means of these tables, the computation of a "*Sumner*" is shortened by one-half.

The line of position at first observation should be drawn as soon as the observations are taken and worked out, and, as the ship is somewhere on this line, the bearing of any land or object it may pass through is at once determined; a single observation yielding such a line of position may, therefore, become very valuable.

When the coast trends parallel to the line of position, the distance of the ship from the shore is ascertained, although her absolute position is undetermined.

Again, a line of position and a cast of the lead, when on soundings, will give the ship's position.

The difference of bearings should not be less than 30° nor greater than 150°, for should the lines of position cut too acutely, the errors of observation will be considerably magnified.

An error in the chronometer places the line of position too far east or too far west, but does not alter its direction.

An error in the altitude will move the line of position nearer or farther from the celestial object, but will not alter its direction.

A line of position obtained in the forenoon is often used, in connection with the latitude circle obtained by meridian altitude, to determine the position of the ship.

REMARKS ON TAKING OBSERVATIONS AT SEA.

Observing Altitudes.—The observer will do well to accustom himself to obtain a single sight with accuracy, and not to depend upon the accidental compensation of errors due to want of care.

The instrument must be vibrated so that the image may skim the horizon, in order to measure the altitude from the point vertically under the body.

The apparent place of the sea horizon differs with different temperatures of the sea and air. When the sea is *warmer* than the air, the horizon appears below its mean place, as that at which it is seen when the air and water are of the same temperature, and the dip taken from the tables is too small; when the sea is *colder* than the air, the horizon appears above its mean place, and then the tabular dip is too great.

These *facts being known*, where great accuracy is required, the

following precautions should be taken: When the altitude of a heavenly body is above 60° it may be observed with the sextant, both from the opposite point of the horizon and from that under it. Half the difference of the two readings is the apparent zenith distance of the centre. By this means the dip and its uncertainties, together with the index error, is removed.

When both the altitude and its supplement are thus measured, and the altitude is in a state of change, the time must be noted at each observation, and the resulting zenith distance will correspond to the mean of the times.

When the altitude of the body is near 90° it is well to ascertain, by reference to the zenith or the compass, the precise point over which the body is vertical.

When fog obscures the horizon from the deck, a new horizon may often be obtained by descending the ship's side, or from a boat.

When the sun's limbs are indistinct, altitudes of the centre may be obtained by bisecting the hazy disk upon the horizon.

When the sky under the moon is unclouded, the upper edge of the illuminated part of the sea is the horizon; but at other times dark shadows are projected on the water, which render it difficult to discern the horizon.

When the moon's altitude and its supplement are both measured, her altitude may be observed as directed in the case of the sun. But in other cases the same limb must be referred to the point of the horizon under her and to that opposite; half the difference is then the apparent zenith distance of the limb observed, and the semi-diameter must be applied accordingly.

When the horizon under the moon is unfavorable for observation, and the supplement of the altitude is alone employed, correct the angle *observed* for index error and dip, take the *supplement* of the result, and apply the semi-diameter as to the altitude seen directly.

The obscurity of the sea horizon often renders it difficult to obtain the altitudes of stars or planets; but in the twilight, when the sky is clear, the horizon is generally well-defined.

When the altitude of a star or planet is measured both from the horizon under it and opposite to it, half the difference of the two angles is the apparent zenith distance. If the supplementary arc alone is used, correct it for index error and dip; the supplement of the result is the apparent altitude.

When a telescope is used, the unemployed eye must be closed; but when the plain tube is used it should be kept open, because the image being seen by both eyes under the same magnitude, one assists the other.

THE RUNNING OF THE WAVES causes the horizon to be in continual motion; while the rise and fall of the observer, both from the lifting of the ship by the waves and her rolling, causes the dip to be continually changing. For this reason a mean of three or five sights should always be taken in rough weather, or in a small vessel. If the altitude be observed above the deck, as in the top, for instance, the horizon will appear better defined, and the variations of the dip caused by the ship's motion will be less sensible; likewise the difference of the temperature of the sea and the air appears to affect the place of the sea horizon less, as the observer is more elevated.

From numerous observations made upon the heights, distances, and velocities of waves, the heights are found to vary from 14 to 36 feet. The distance from crest to crest of such waves is from 150 to 350 feet, while their velocity appears to vary between 15 and 29 nautical miles per hour.

When the observer nears or recedes from the celestial body, by the progress of the vessel, the effect produced on the altitude is the same as that of a motion in the body itself. Accordingly, in all observations in which, from the sensible change of altitude, the time requires to be noted at each observation, the progress of the ship is included in the observed change of altitude; and the *place* to which the observation corresponds is that at which the ship was at the mean of the times.

SHORE HORIZON.—It sometimes happens that the horizon is concealed by the intervention of land, while the level surface of the water marks on the shore a distinct horizontal line, which may be used as a substitute for the sea horizon, and is known as the *shore* horizon. When its distance is not known, it may be found by means of two altitudes—the one being observed from the deck, and the other from aloft—at the same time.

RULE.—Divide the difference of the heights in feet, by the number of *minutes in the difference* of the altitudes; the quotient is the

number of feet subtending an angle of 1′ at that distance. Enter the following table with the number of feet, and the corresponding distance is that required :

Number of Feet Subtending an Angle of 1′.

Miles.	Feet.	Miles.	Feet.	Miles.	Feet.	Miles.	Feet.
1	1.77	9	15.92	17	30.07	25	44.23
2	3.54	10	17.69	18	31.84	26	46.00
3	5.31	11	19.46	19	33.61	27	47.76
4	7.08	12	21.23	20	35.38	28	49.53
5	8.84	13	23.00	21	37.15	29	51.30
6	10.61	14	24.77	22	38.92	30	53.07
7	12.38	15	26.53	23	40.69	31	54.83
8	14.15	16	28.30	24	42.46	32	56.60

When the distance of the shore horizon is known, enter the following table with this distance and the height of the eye, and use the correction instead of the dip ordinarily applied :

Dip of the Shore Horizon.

Distance in miles.	Height of eye in feet.						
	5	10	15	20	25	30	35
	′	′	′	′	′	′	′
½	6	12	17	23	28	34	40
1	3	6	9	12	15	17	20
1½	3	4	6	8	10	12	14
2	2	4	5	7	8	9	11
2½	2	3	4	6	7	8	9
3	—	3	4	5	6	7	8
3½	—	3	4	5	6	6	7
4	—	3	4	5	5	6	7
5	—	—	4	4	5	6	6

Example.—An observer at the height of 89 feet above the sea, observed the sun's altitude 41° 37′ above the shore horizon ; another

observer at the height of 20 feet, observed it 41° 25′: find the distance of the water-line, and correct the altitude for dip.

The difference of the heights, 69 feet, divided by 12, the difference of the altitudes in minutes, gives 5.7 feet, which answers in the table to 3 miles, the distance required. The correction in the table, dip of shore horizon, to 3 miles, and height, 20 feet, is 5′, which, *subtracted* from the altitude taken at 20 feet, gives 41° 20′, the altitude corrected for dip.

Reduction of an Altitude to Another Place of Observation.—The run of the ship in the interval between the taking of the two altitudes which constitute certain observations, renders it necessary to reduce one to the place of the other.

When the ship approaches the sun directly, she raises it 1′ for each mile of distance made good; and likewise when the ship recedes from the sun, she drops it the same amount.

TO REDUCE THE 1ST ALTITUDE TO THE SECOND PLACE OF OBSERVATION.—Take the difference between the bearing of the body at the first observation and the ship's course, *made good*, with which, as a course, enter the transverse table, and take out the difference of latitude corresponding to the distance run between the observations. This is the correction for run. Add this to the first altitude if the number of points between the sun's bearing and the ship's course be less than eight; but subtract it if the number of points be more than eight; the result is the altitude reduced to what it would have been if observed at the same place where the second was.

TO REDUCE THE 2D ALTITUDE TO THE FIRST PLACE OF OBSERVATION.—Take the bearing at the second observation; find the reduction of the altitude as above, and apply it to the 2d altitude the contrary way to that directed in the case of the 1st altitude.

Observing Altitudes on Shore.

Altitudes may be observed on shore, above the sea horizon, from a hill of known height, or by the assistance of the *artificial horizon.*

Artificial Horizon.—In using the artificial horizon, care must be taken in pouring out the quicksilver. Place the finger over the orifice of the bottle, and invert it over the trough, which must be previously well cleaned. Give the bottle a shake, then ease the finger,

and allow the mercury to flow slowly, holding the bottle steady, and being careful to close the opening before the last portion, with the dross, appears. If carefully done, a brilliant surface will be produced. In placing the artificial horizon, see that the shadow is thrown directly behind it, and not on either side. If observations are taken on one side of the meridian only, it is advisable to reverse the roof in obtaining them, but with observations on both sides of the meridian, the same glass should be always toward the observer. A mark should be placed on the glass, or on the framework, to insure this precaution being carried out.

The spot chosen for observation should be sheltered from the wind, and, to be free from vibration, removed from traffic.

In taking altitudes of the *lower* limb in the mercury, the *lower* limb of the object is made to touch the upper limb of the image in the horizon, as reflection inverts the object.

In taking the altitude of the *upper* limb, the image of the body is brought below the quicksilver image altogether. Therefore, when the sun is *rising*, and the lower limb is observed, the images are continually *separating*; but when the upper limb is observed, they are continually *overlapping*, and the *reverse* when the sun is falling.

It is recommended to attend to this, as it is often doubtful, especially with the inverting telescope, which limb has been observed.

Night Observations.—Obtaining latitudes at night with the artificial horizon requires practice. See it placed in the true meridian before the observations are commenced. The approximate mean times of the meridian passages of the stars to be used should be computed from the "Nautical Almanac;" the error on mean time of the watch in use should then be applied to them. These times of meridian passage, *as shown by the watch* in use, may be entered in the sight-book as a guide to the observer, together with the approximate meridian altitudes.

The stars selected should be of convenient altitudes, neither too high nor too low. Care should be taken to find the reflected image in the mercury some little time before it comes on the meridian.

In observing stars north and south of the zenith, for latitude, care should be taken to pair those of about the same altitude; therefore, in the Northern Hemisphere the best south stars to pair with Polaris are those whose meridian altitudes are nearly the same as the latitude of the place.

Similarly, in taking lunars, stars lying at about equal distances east and west of the moon should be selected.

A sailor should be trained to hold the lantern by which the observations must first be noted by the watch, and then read from the sextant in such a manner that, while the assistant who is taking time can see the watch, no light is thrown toward the artificial horizon. On the time being secured, the light is taken to the observer with the sextant. The roof of the horizon may require wiping occasionally, on account of the dew.

Observing without Assistants.—When the observer takes the whole observation himself, he can estimate his results at their real value, of which he can be no judge when they are taken by other persons.

When the observer takes his own time, he may hold the watch in his hand, or place it where he can obtain sight of it readily, or where he can hear it tick plainly.

In the latter case, the first beat after the instant of contact he counts 1, the next 2, etc.; then, looking at the watch, he counts on till the second hand arrives at a marked number of seconds, as 15, 20, etc.; he then writes down these seconds, and after them the number of beats counted, to be *subtracted*.

The altitude is then read off and recorded. Most watches beat five times in 2 sec., or each beat =0.4 sec. The sum of the beats should be deducted before the mean of the times is obtained.

Example.—After contact, 14 beats are counted; the second hand is then at 30 sec., the minute 42, and the hour 10, and so on, as follows:

	H. M. S.		BEATS.
	10 42 30	subtract	14
	10 44 10	"	32
	10 46 00	"	11
	132 40		57=22.8 sec.
	22.8		
3)	132 17.2		
Mean....	*10 44 5.7*		

CARE OF CHRONOMETERS.

(*Shadwell and Bedford.*)

WHEN chronometers are received on board ship, it is of importance that they should be at once stowed away in the place prepared for them; and when once suitably located they should on no account be subjected to removal or displacement.

The chronometers should be placed low down in the ship (both because there is less motion, and because the temperature is more equable) amidships; as far from the extremities, and as near the centre of gravity as convenient; not near the chain-cables, or other large masses of iron, so as to insure freedom from the disturbance of magnetic influence; and not in drawers, as the tremor caused by opening and shutting acts injuriously on their balances.

The best mode of stowing them is as follows: a box, divided into as many partitions as there are chronometers to be stowed, should be securely attached by screws to a solid block of wood, about thirty inches in height, and firmly bolted to the beams of the deck below.

Each partition should, in depth, be about equal so that of the largest box of the chronometers to be stowed away, and in length and breadth about two inches larger than the sides of the box it is intended to secure. Great care should be taken that the block and box thus prepared should be entirely detached from all contact with contiguous stanchions or bulkheads; both block and box, moreover, should be surrounded with a strong external casing, the sides and lid of which should on no account be permitted to touch it, a clear space of at least two inches being left all round. Previous to placing the boxes containing the chronometers within the partitions appropriated for them, it will generally be found convenient to unscrew and altogether detach their lids; because, if this be not done, when open they occupy much more room, and will require the partitioned spaces for their reception to be made inconveniently large.

Each chronometer in its box thus prepared, and moving freely in its gimbals, is then to be placed in the space allotted to it on a bed of dry sawdust, horsehair, or cotton, about three inches thick—the spaces around the sides of each box being stuffed with the same material to within half an inch of the top of the box. Of the three substances named above, dry sawdust is preferred.

The marks on the dial-plate of the chronometers should all occupy the same relative positions: that is, the line joining the XII. and VI. hour marks should all be parallel to one another, both for the sake of the convenience of comparison, and in order that, retaining the same invariable position with reference to the fore and aft line of the ship, they may be similarly affected by the local magnetic attraction of the ship's iron, and that in cases where the balances of the chronometers have accidentally acquired any degree of polarity, their mutual influences on each other may be reciprocal.

Generally speaking, it is not the custom to receive the chronometers on board the ship until a few days before leaving the harbor, the time of the officers who will subsequently be charged with the duty of superintending their performances being at that period much occupied with other important matters connected with the equipment of the ship; but, as from the influences of the new circumstances under which the chronometers are placed, the effects of motion in removing them, change of temperature, and possible action of magnetic causes, their rates, after a while, may differ from their previous rates on shore, it is very advisable, when practicable, that they should be received on board at an earlier period, so that they may become *naturalized* in their new position, and may have settled down to a stability of rate under their new conditions before the ship is called on to proceed to sea.

The chronometers having been received on board and stowed away, in the manner above described, in the place appropriated for their reception, it is of importance at once to commence and adopt an uniform and systematic manner of winding them up, and comparing them daily with one another. Methodical arrangements in these particulars favor the stability of rate of the chronometers, assist in the detection of irregularities, and diminish the probabilities of their being accidentally allowed to run down; while, in the reduction of chronometric observations for the determination of meridian distances, systematic plans of comparison are indispensable to accuracy of computation.

As a rule, 8 A.M. is a time conveniently adapted to this duty, and consistent with the arrangements of a man-of-war.

The chronometers should be wound *first* and compared *afterwards*. In winding them, they should be habitually attended to in the same order from day to day, one by one, as they lie in their places, so

that the mechanical habits of regularity in this particular may be a safeguard against the caprice of memory, or accidental distraction from any disturbing cause. From want of system in this particular, we have known instances where the attention of the officer engaged in this duty being accidentally distracted during its performance, the chronometers have been compared, but some or all of them not wound up, that operation being forgotten, and the omission not detected till the chronometer ran down. In winding up chronometers, the turns of the key should always be counted, and the last turn made gently and carefully, *until it is felt to butt.*

In winding up box-chronometers, the chronometer should be inverted carefully in its gimbals, held firmly in the left hand, and the key pressed home with the right; after the operation is performed, and the key withdrawn, care should be taken that the keyhole is again covered with the slider to secure it from dust or damp, and then the chronometer should be *gently eased down* into its natural position without violence or jerk.

In winding up pocket-chronometers, the watch should be held firmly in the left hand, with the wrist pressed gently against the breast; the key should be turned equably and steadily with the right, care being taken to avoid giving the watch any circular motion upon the key. The vicious practice of turning the left as well as the right hand is injurious, for two reasons: first, because the circular motion affects the regularity of the balance; and secondly, because the compound motion of the hands doubles the velocity of winding, and increases the chances of straining or snapping the spring from the jerk at the conclusion of the operation.

Chronometers should be wound *daily*, whether constructed to run for one or two days; eight-day chronometers once a week—say on Sunday, a day easily remembered. If the number of chronometers is large, the precaution should be taken of examining them after winding, by looking at the winding-index on the dial-plate.

The chronometers having been all wound, they should next be compared. To facilitate their systematic comparison, and to organize the reduction of chronometric observations, it is customary to select one chronometer as a *standard*, to which all observations for the determination of the time are in the first instance referred; the indications of the other chronometers at the same moment being subsequently obtained by means of the comparisons.

The chronometer selected to perform the duty of the "standard" should occupy a central position among the chronometers, for facility of comparison. It should be of first-rate character, and by a maker of established repute. It will be convenient that it should have a clear and distinct beat; also that its dial plate be well marked, and it is advisable that its rate should be small. Stability of rate, however, is more important than the smallness of its amount.

It is desirable, when practicable, that the comparisons of the chronometers with the standard should all be made by one person. The effects of personal equation are thereby much simplified, and the chances of small contingent errors materially diminished.

The navigator should never be content to use the rates he may receive with the chronometers on their leaving the shore, when they are "not naturalized in their new positions." Pressure of business may necessitate the use, for a time, of the observatory rate, but the earliest opportunity should be taken to get a new rate, and the performance of these delicate instruments should be closely watched.

It is advisable that the rate of a chronometer should not depend on observations made at an interval of less than *five*, or more than *ten* days. Seven days will be found a good average interval, and in the case of eight-day chronometers, moreover, it embraces the period affected by the entire length of chain.

With the above limitations, it may be laid down as a maxim, that chronometers cannot be rated too often when time and opportunity permit.

The error and rate of the chronometer should, if possible, be obtained by observing equal altitudes of the sun; failing this, by forenoon or afternoon sights, taking care that if the observations on the first day are made in the forenoon, those on the second day should also be made in the forenoon, and *vice versa*.

The hack used in rating chronometers should be carried in a box, and should be compared with the standard chronometer on leaving and returning to the ship.

Practice will soon make the navigator an expert observer, and, in addition to the safe conduct of his ship, he will often be able, by measuring meridian distances, to be of great assistance to his fellow seamen, by furnishing them with the longitudes of places hitherto unknown. The following table from Bedford will show by what a simple method chronometers may be rated and a meridian distance measured.

Meridian Distance between Beirut and Sidon.

Losing rates are marked —; gaining rates marked +.

Numbers of Chronometers.	Dent, 1,798 Standard.			McCabe, 187.			Frodsham, 2,714		
	H.	M.	S.	H.	M.	S.	H.	M.	S.
Standard fast on Beirut mean time, June 17, 1861...........	7	15	00.79	7	15	00.79	7	15	00.79
Comparisons (standard being fast on chronometers)*...........			——	9	11	15.00	9	35	15.00
Chronometers fast on Beirut mean time, June 17, 1861.	7	15	00.79	10	03	45.79	9	39	45.79
Ditto ditto, June 11, 1861..	7	15	11.68	10	03	43.68	9	39	41.68
Rate in six days.................			10.89			2.11			4.11
Daily rate......................	—		1.81	+		.35	+		.68
Sidon rates in June.............	—		1.91	+		.18	+		.59
Beirut-Sidon rate...............	—		1.86	+		.26	+		.63
Chronometers fast on Beirut mean time, June 17, 1861...........	7	15	00.79	10	03	45.79	9	39	45.79
Rate in three days by Beirut-Sidon rate.....................	—		5.58	+		.78	+		1.89
Chronometers fast on Beirut mean time, June 20th.......... ...	7	14	55.21	10	03	46.57	9	39	47.68
Chronometers fast on Sidon mean time, June 20th.............	7	15	25.91	10	04	16.91	9	40	18.41
Meridian distance, Beirut and Sidon.............			30.70			30.34			30.73

s.		
30.70	Longitude of Beirut..	35° 29′ 04″ E.
30.44		— 7 39
30.73		
.177	Longitude of Sidon............	35 21 25 E.
30.59=7′ 39″		

* *It will be found convenient, in working out the rates of chronometers and meridian distances, always to consider the chronometers as fast.*

An excellent method has been afforded of late years of determining the error and rate of the chronometer, by the establishment of *time balls* at certain ports, controlled and dropped from some observatory. These time balls obviate the necessity of observations for rate.

TIME.

ASTRONOMERS make use of several different kinds of time: mean solar time; true or apparent time; and sidereal time.

Solar Time.—Solar time is that used for all the ordinary purposes of life, and is measured by the daily motion of the sun. A *solar day* is the interval of time between two successive transits of the sun over the same meridian, and the hour angle of the sun is called *solar time.*

This is the most natural and direct measure of time. But the intervals between the successive returns of the sun to the same meridian are not exactly equal, owing to the varying motion of the earth round the sun, and to the obliquity of the ecliptic. The intervals between the sun's transits over the meridian being unequal, it is impossible to regulate a time-piece so that it shall follow the sun.

To avoid the irregularity which would arise from using the true sun as the measure of time, a fictitious sun, called a *mean sun*, is supposed to move in the equator with a uniform velocity. This mean sun is supposed to keep, on the average, as near the real sun as is consistent with perfect uniformity of motion; it is sometimes in advance of it, and sometimes behind it, the greatest difference being about 16 minutes.

MEAN SOLAR TIME, which is perfectly equable in its increase, is measured by the motion of this mean sun.

The clocks in ordinary use, and the chronometers used by navigators, are regulated to mean solar time. Mean solar time is generally called *mean time* simply.

TRUE OR APPARENT SOLAR TIME is measured by the motion of the real sun. The difference between apparent and mean time is called the *equation of time;* by means of it we change apparent to mean time, or the reverse.

Sidereal Time.—Sidereal time is measured by the daily motion of the stars; or, as it is used by astronomers, by the daily motion of that point in the equator from which the true right ascensions of the stars are counted. This point is the vernal equinox, and its hour angle is called sidereal time. Clocks regulated to sidereal time are called sidereal clocks.

A Sidereal Day is the interval of time between the transit of the vernal equinox over any meridian and its next succeeding return to the same meridian. It is about 3 m. 56 s. shorter than the mean solar day: 365¼ solar days, or a year, being divided into 366¼ sidereal days. It is divided into 24 hours. The sidereal hours are counted from 0 to 24, commencing with the passage of the vernal equinox over the upper meridian, and ending with its return to the same meridian. About March 21st of each year, the sidereal clock agrees with the mean time or ordinary clock, and it gains on it about 3 m. 56 s. per day, so that at the end of a year it will have gained an entire day, and will again agree with it.

The Civil Day commences at midnight, and comprises twenty-four hours from one midnight to the next following. The hours are counted from 0 to 12 from midnight to noon, after which they are again reckoned from 0 to 12 from noon to midnight. Thus the day is divided into two periods of 12 hours each, the first of which is marked A.M., the last is marked P.M.

The Astronomical Day commences at noon on the civil day of the same date. It also comprises twenty-four hours; but they are reckoned from 0 to 24 hours, and from the noon of one day to that of the next following.

The astronomical as well as the civil time may be either apparent or mean, according as it is reckoned from apparent noon or from mean noon.

The civil day begins twelve hours before the astronomical day; therefore the first period of the civil day answers to the last part of the preceding astronomical day, and the last period of the civil day corresponds to the first part of the same astronomical day. The rule then for the transformation of civil time into astronomical time is this: *if the civil time is marked* A.M. *take one from the day and add twelve to the hours*, and the result is the required astronomical

time; *if the civil time is marked* P.M., *take away the designation* P.M. and the astronomical time is obtained without change.

To change astronomical to civil time, we simply write P.M. *after it*, if it is less than twelve hours. If greater than twelve hours, we subtract twelve hours from it, add one to the days, and write A.M.

If the longitude from Greenwich be expressed in time, and when *west* added to the local time, or when *east* subtracted from the local time, the result is the corresponding Greenwich time. If the local *mean* time is used, the result is the Greenwich *mean* time. The rule is the same whether we use mean or sidereal time.

For general convenience, the time changing continually during a passage, *apparent time* is kept on board ship at sea. This fact must be remembered, if looking out for the meridian passage of stars to determine latitude.

Lunar Day.—The average duration of a lunar day, or the interval that elapses between two successive transits of the moon over the meridian of the same place, is 24 h. 54 m.; the average period of the moon's revolution round the earth is 27 d. 7 h. 43 m. 11.5 s.; while the interval between new moon and new moon is 29 d. 12 h. 44 m. 2.9 s.

Year.—The earth completes her revolution round the sun in 365 d. 6 h. 9 m. 9 6 s., mean solar time, or in 366d. 6 h. 9 m. 9.6 s. reckoned in sidereal time. This is called the sidereal year. But the year in which mankind in general are most interested, is the tropical year of 365 d. 5 h. 48 m. 49.7 s.

This year, on which the return of the seasons depends, is the interval between two successive arrivals of the sun at the vernal equinox, or first point of Aries, and differs from the sidereal year by reason of the motion of the equinoctial points, known as the *precession of the equinoxes.*

The tropical year is a compound phenomenon, depending chiefly and directly on the annual revolution of the earth round the sun, but subordinately and indirectly on its rotation round its own axis. The Gregorian Calendar, now generally used among civilized nations, depends upon this tropical year, and may be thus briefly described:

Every year whose number is not divisible by four without a remainder consists of 365 days; every year which is divisible by 4, but is *not divisible by 100, of 366* days; every year divisible by 100,

but not by 400, consists again of 365; and every year divisible by 400, consists of 366 days. For example:

1873, not being divisible by 4, consists of 365 days.

1876, being divisible by 4, but not by 100, consists of 366 days.

1800 and 1900, being divisible by 100, but not divisible by 400, consist of 365 days each.

2000, being divisible by 400, consists of 366 days.

The error of the Gregorian Calendar amounts to only 0.944 days in 4,000 years.

Conversion of Time and Arc.

To turn Time into Degrees, Minutes, and Seconds of Arc.

RULE.—Turn the hours into minutes and divide by 4; the result will be degrees, minutes, and tenths of a minute of arc.

Example—7 h. 40 m. 53.73 s. = 460 m. 53.73 s. $\div$ 4 = 115° 13′.43 = 115° 13′ 26″.

To turn Arc into Hours, Minutes, and Seconds of Time.

RULE.—Multiply the arc by 4; this converts the degrees into minutes, minutes into seconds, and the seconds into thirds of time.

Example.—115° 13′ 26″ × 4 = 460 m. 53 s. 44 t. = 7 h. 40 m. 53.73 s.

To Convert Sidereal and Mean Time Intervals Approximately.

To Convert a Mean Time into a Sidereal Time Interval.

RULE.—Increase the interval by 1 m. for every six hours, or by 10 s. for each hour, or by 1 s. for every six minutes.

To Convert a Sidereal into a Mean Time Interval.

RULE.—Diminish the interval by 1 m. for every six hours, or by 10 s. for each hour, or by 1 s. for every six minutes.

For Converting Intervals of Mean Solar Time into Equivalent Intervals of Sidereal Time.

Hours.		Minutes.		Seconds.		Fractions of a second.	
Mean time.	Equivalents in sidereal time.	Mean time.	Equivalents in sidereal time.	Mean time.	Equivalents in sidereal time.	Mean time.	Equivalents in sidereal time.
H.	H. M. S.	M.	M. S.	S.	S.	S.	S.
1	1 0 9.856	1	1 0.1643	1	1.0027	0.01	0.0100
2	2 0 19.713	3	3 0.4928	3	3.0082	0.04	0.0401
3	3 0 29.569	5	5 0.8214	5	5.0137	0.07	0.0702
4	4 0 39.426	7	7 1.1499	7	7.0192	0.10	0.1003
5	5 0 49.282	9	9 1.4785	9	9.0246	0.13	0.1303
6	6 0 59.138	10	10 1.6428	10	10.0274	0.16	0.1604
7	7 1 8.995	11	11 1.8070	11	11.0301	0.19	0.1905
8	8 1 18.851	13	13 2.1356	13	13.0356	0.22	0.2206
9	9 1 28.708	15	15 2.4641	15	15.0411	0.25	0.2507
10	10 1 38.564	17	17 2.7927	17	17.0465	0.28	0.2808
11	11 1 48.421	19	19 3.1212	19	19.0520	0.30	0.3008
12	12 1 58.277	20	20 3.2855	20	20.0548	0.31	0.3108
13	13 2 8.134	21	21 3.4498	21	21.0575	0.34	0.3409
14	14 2 17.990	23	23 3.7783	23	23.0630	0.37	0.3710
15	15 2 27.847	25	25 4.1069	25	25.0685	0.40	0.4011
16	16 2 37.703	27	27 4.4354	27	27.0739	0.43	0.4312
17	17 2 47.560	29	29 4.7640	29	29.0794	0.46	0.4613
18	18 2 57.416	30	30 4.9282	30	30.0821	0.49	0.4913
19	19 3 7.273	31	31 5.0925	31	31.0839	0.50	0.5014
20	20 3 17.129	33	33 5.4211	33	33.0904	0.52	0.5214
21	21 3 26.985	35	35 5.7496	35	35.0958	0.55	0.5515
22	22 3 36.842	37	37 6.0782	37	37.1013	0.58	0.5816
23	23 3 46.698	39	39 6.4067	39	39.1068	0.61	0.6167
24	24 3 56.555	40	40 6.5710	40	40.1095	0.64	0.6417
		41	41 6.7353	41	41.1123	0.67	0.6718
		43	43 7.0638	43	43.1177	0.70	0.7019
		45	45 7.3924	45	45.1232	0.73	0.7320
		47	47 7.7209	47	47.1287	0.76	0.7621
		49	49 8.0495	49	49.1342	0.79	0.7922
		50	50 8.2137	50	50.1369	0.82	0.8222
		51	51 8.3780	51	51.1396	0.85	0.8523
		53	53 8.7066	53	53.1451	0.88	0.8824
		55	55 9.0351	55	55.1506	0.90	0.9025
		57	57 9.3637	57	57.1561	0.91	0.9125
		59	59 9.6922	59	59.1615	0.94	0.9426
		60	60 9.8565	60	60.1643	0.97	0.9727

Converting Intervals of Sidereal Time into Equivalent Intervals of Mean Solar Time.

Hours.		Minutes.		Seconds.		Fractions of a Second.	
Sidereal time.	Equivalents in mean time.	Sidereal time.	Equivalents in mean time.	Sidereal time.	Equivalents in mean time.	Sidereal time.	Equivalents in mean time.
H.	H. M. S.	M.	M. S.	S.	S.	S.	S.
1	0 59 50.170	1	0 59.8362	1	0.9973	0.01	0.009[illegible]
2	1 59 40.340	3	2 59.5085	3	2.9918	0.04	0.039[illegible]
3	2 59 30.511	5	4 59.1809	5	4.9864	0.07	0.069[illegible]
4	3 59 20.681	7	6 58.8532	7	6.9809	0.10	0.099[illegible]
5	4 59 10.852	9	8 58.5256	9	8.9754	0.13	0.129[illegible]
6	5 59 1.022	10	9 58.3617	10	9.9727	0.16	0.159[illegible]
7	6 58 51.193	11	10 58.1979	11	10.9700	0.19	0.189[illegible]
8	7 58 41.363	13	12 57.8703	13	12.9645	0.22	0.219[illegible]
9	8 58 31.534	15	14 57.5426	15	14.9591	0.25	0.249[illegible]
10	9 58 21.704	17	16 57.2150	17	16.9536	0.28	0.279[illegible]
11	10 58 11.874	19	18 56.8873	19	18.9481	0.30	0.299[illegible]
12	11 58 2.045	20	19 56.7235	20	19.9454	0.31	0.309[illegible]
13	12 57 52.215	21	20 56.5597	21	20.9427	0.34	0.3391[illegible]
14	13 57 42.386	23	22 56.2320	23	22.9372	0.37	0.3690[illegible]
15	14 57 32.556	25	24 55.9044	25	24.9318	0.40	0.3989[illegible]
16	15 57 22.727	27	26 55.5767	27	26.9263	0.43	0.4288[illegible]
17	16 57 12.897	29	28 55.2490	29	28.9208	0.46	0.4587[illegible]
18	17 57 3.067	30	29 55.0852	30	29.9181	0.49	0.4887[illegible]
19	18 56 53.238	31	30 54.9214	31	30.9154	0.50	0 4986[illegible]
20	19 56 43.409	33	32 54.5937	33	32.9099	0.52	0 5186
21	20 56 33.579	35	34 54.2661	35	34.9045	0.55	0.5485
22	21 56 23.749	37	36 53.9384	37	36.8990	0.58	0.5784
23	22 56 13.920	39	38 53 6108	39	38.8935	0.61	0.6083
24	23 56 4.090	40	39 53.4470	40	39.8908	0.64	0.6382
		41	40 53.2831	41	40.8881	0.67	0.6682
		43	42 52.9555	43	42.8826	0.70	0.6981
		45	44 52.6278	45	44.8772	0.73	0.7280
		47	46 52.3002	47	46.8717	0.76	0.7579
		49	48 51.9725	49	48.8662	0.79	0.7878
		50	49 51.8087	50	49.8635	0.82	0.8178
		51	50 51.6449	51	50.8608	0.85	0.8477
		53	52 51.3172	53	52.8553	0.88	0.8776
		55	54 50.9896	55	54.8499	0.90	0.8975
		57	56 50.6619	57	56.8444	0.91	0.9075
		59	58 50.3343	59	58.8389	0.94	0.9374
		60	59 50.1704	60	59.8362	0.97	0.9673

Section 5.

BLOCKS, TACKLES, AND ROPE.
VARIOUS KINDS, PRACTICAL RULES, ETC.

WIRE-RIGGING, CUTTING AND FITTING.

CABLES. DATA CONCERNING CHAIN CABLES, WIRE CABLES.

ANCHORS. RULES FOR WEIGHTS AND DIMENSIONS.

SAILS, CANVAS, ETC., REMARKS ON.

PAINTING SHIP.
MIXING COLORS, VARNISHES, ETC. STAINING AND DYEING.

MISCELLANEOUS RECIPES.

TIMBER PRESERVATION AND SEASONING.

INTERNAL ECONOMY.
SCRAPING SPARS, CLEANING DECKS, REPLACING COPPER, DRESSING SHIP, ANCHORING IN FOREIGN PORTS, STOWING PROVISIONS, ETC., ETC.

EXTEMPORARY MEASUREMENTS.

BLOCKS.

BLOCKS are mechanical contrivances, possessing the properties of pulleys. A block consists of the *shell*, *sheave*, *pin* and *strap*. The shell is the frame or outside part, and is usually made of ash. In the *made* block it consists of two or more pieces pinned together, the outside pieces being called the *cheeks*. In the *morticed* block the shell is composed of but one piece of wood, morticed out to receive the sheave.

On the sides and at each end of the shell of a block, a single or double score is cut to allow the strap to fit snugly on the block.

The sheave is the roller over which the rope runs, and is made of metal or lignum-vitæ. It has a hole in the centre to receive the pin, which may be of iron or copper, hardened.

In a lignum-vitæ sheave, the pin-hole is usually *bouched*, or lined with composition to protect the sheave from chafe. In what are known as *patent blocks* the sheave contains *friction rollers*, and these are now generally used in cases where the blocks are not subject to great strain.

The *strap* is the rope or band around the shell, by which it is attached to its particular place.

The *swallow* is the aperture through which the rope reeves. The *hook* is attached to the strap, and is prevented from chafing by means of a *thimble*. The *breech* is the end of the block farthest from the hook.

Blocks are *single*, *double*, *treble*, or *fourfold*, according to the number of sheaves contained within the shell. The size of a block is determined by the length of the shell. The sizes in general use in the Navy range from 4 inches to 24 inches inclusive.

Under the general name of blocks may be included *hearts*, *dead-eyes*, and *bull's-eyes*, which receive the ends of stays and shrouds, *wooden thimbles*, *fairleaders*, *euphroes* for awnings, *cleats*, *cavils*, *wooden rollers*, *chocks*, *toggles*, *travellers*, *wooden-hanks*, *hoops*, *trucks*, etc.

Blocks take their names from some peculiarity of form; from the position they occupy; or from the purpose to which they are applied.

Bee-blocks, or bees, are pieces of oak bolted to the bowsprit, for the fore-topmast and spring stays to reeve through.

Cat-block is a large block, usually treble, used to raise the anchor to the cathead.

Cheek-blocks are half shells which bolt against a mast or spar, which forms the other half shell. Used on gaffs for brails, etc.

Clump-blocks are short and thick, as the tack and sheet blocks.

Clew-garnet-blocks are single blocks hanging under the quarters of the lower yards, and receive the clew-garnets by which the courses are hauled up. The same name is applied to the blocks which hook in the clews of those sails.

Clew-line-blocks are attached to the clews of the topsails for the clew-lines.

Dasher-block is a block at the end of the spanker gaff for reeving the ensign halliards.

Euphroe is a long piece of wood, having a number of holes in it, through which the *crow-foot* for the awning is rove.

Fiddle-block has a long shell, with one sheave over the other. Used for yard tackles and top burtons.

Fly-block is the upper block of the topsail halliards.

Gin-blocks are large composition sheaves which turn in a metal framework.

Girtline-blocks are single blocks used to reeve single whips called girtlines or *gantlines*.

Hanging-blocks are used at the mastheads for the halliards of the jibs and staysails. They usually have friction rollers.

Jack-blocks are single blocks, sometimes used for sending up and down light yards.

Jeer-blocks are large treble or fourfold blocks for reeving the purchases for sending up and down lower yards.

Jewel-blocks are single blocks at the ends of the yards, used to reeve studding-sail halliards.

Main sheet-block is a double or treble block, strapped or hooked to the main-boom of a schooner or sloop, for the main-sheet.

Quarter-blocks on the topsail and topgallant yards, are double

blocks to give lead to the sheet of the sail above and clewline of the one below. On the lower yard they are single for the topsail sheet, and on royal yards are single for the royal clewline.

Shoe-blocks are a single piece of wood, with mortices cut so that the two sheaves may turn at right angles to each other.

Sister-blocks are formed of one shell and two sheaves one above the other. Generally used between the two forward shrouds of topmast rigging to give lead to the topsail lift and reef-tackle.

Secret-blocks are so made that the sheave is entirely screened, to prevent fouling by small gear catching in the swallow. Used for clew-lines and clew-jiggers.

Snatch-blocks are single and iron bound, with a swivel hook. The shell is open at the breech, and the strap fitted with a clamp, so that the bight of a rope can be snatched.

Telegraph-blocks are blocks with a number of small sheaves, used for making signals.

Top-blocks are large single blocks used for sending up and down topmasts.

Tye-blocks are large single blocks which shackle to bands on the topsail yard for the tyes to reeve through.

Viol-blocks are large single blocks used with hawsers.

Block and *block*, or two blocks, is the term applied to a tackle when its blocks have been drawn together. *Fleeting* or *overhauling* the tackle is the act of drawing the blocks apart again. Blocks require frequent examination, and pins and sheaves should be frequently transposed to prolong the life of the block. The sheaves on which the hauling part works does the most duty. All blocks which stand horizontally must be placed with the head of the pin upward. Great support may be given to the hook of a block by slipping a shackle over the point.

Block-straps.—When not iron-strapped, blocks are fitted with straps of hemp-rope, which should always be well stretched.

A rough rule for the size is *that the rope should be in circumference one-third the length of the block.*

Once and a half the round of the block is a good measure for the common strap. The splice should be at the breech of the block.

All blocks under twelve inches should be measured with a piece of spun-yarn, in the score; and those above twelve inches with six to twelve-thread ratline-stuff.

Cutting and Fitting Straps.

Single Block with Lashing Eyes.—Twice the round of the block, and once the round of the rope, will give the length to cut the strap. Marry the rope once and a half round of block, and half the round of rope.

Single Block with Hook and Thimble.—Twice the round of block and once the round of rope for length. The round of block, rope, and thimble, is the length to marry the strap.

A Single Block with Double Scores.—For a double strap passing around a yard and the bights, lash on top of the yard. Twice and a half the round of block, twice the round of yard, and once and a half the round of rope. Marry the strap at twice the round of the yard and block, and once the round of the rope.

Double Block with Hook and Thimble.—Take twice the round of the block for length, and marry it once the round of block, once round of thimble, and two-thirds the round of the rope.

Brace Blocks for Lower Yards.—Fitted with a double strap. Twice round of block, twice the round of thimble, and three times the round of rope. Allow sufficient to splice.

Sizes of Rope Reeving in Blocks.—For an ordinary thick block, take one-third its length for the size of rope to reeve, namely, a nine-inch block will reeve a three-inch rope.

For a clump-block, take one-half its length.

For a thin block, one-fifth the length.

For a fiddle-block, one-sixth the length.

TACKLES.

TACKLES are combinations of ropes and blocks used as a mechanical power for moving or raising weights.

They are variously applied on ship-board for sending aloft masts and yards, setting or taking in sails, setting up rigging, and in moving guns, anchors, etc.

The simplest form of tackle is that in which a single fixed block is used. By this arrangement a better lead is given the rope, and the power is more conveniently applied, but *no power is gained.* If the single block be attached to the weight to be raised—one end of the rope being secured, and the power applied to the other end—the lifting power is doubled, as the weight is then sustained by two parts of the rope, each of which bears half the strain. Should the rope be passed through another fixed block, greater convenience is obtained in the application of the power, though the lifting power is unchanged. Therefore the ratio of the moving power of a tackle to the applied power depends upon the number of parts of rope at the *movable* block.

In order to exert the greatest amount of power with a tackle, *that block having the greatest number of parts of rope* should be attached to the weight to be moved.

To ascertain the amount of purchase required to raise a given weight with a given power, *divide the weight by the power*, and the quotient will be the number of parts of rope which the lower block should contain, or $N=\frac{W}{P}$, and again $P=\frac{W}{N}$, or the power necessary to raise a given weight with a tackle is *equal to the quotient of the weight divided by the number of parts at the movable block.*

If the weight is raised by such an increase in the power applied as shall set the sheaves in motion, the element of *friction* must be considered.

Friction causes the tension upon the various parts of the rope to be unequal. The hauling part will bear the greatest strain, while the standing part will bear the least strain. Each intermediate part will sustain its proportionate part of the weight, increased by the friction of each sheave between it and the standing part. It has been estimated that one-sixth of the power gained at each sheave is expended in overcoming the friction, and the ordinary rule is that the hauling part bears double the strain of the standing part in moving a weight.

Power can be increased only at the expense of time; or, the velocity with which the power moves, is to the velocity with which the weight rises as the number of parts at the movable block is to 1.

Tackles of various sizes and powers are in use on board ship, and they are named from the uses to which they are applied.

A *single whip* has a single fixed block.

A *gun-tackle purchase* has two single blocks.

A *luff-tackle* has a double and single block.

A *twofold purchase* has two double blocks.

A *threefold purchase* consists of two treble blocks.

A *boom-tackle* is a double purchase used in fore and aft rigged vessels in guying out the main boom with a fair wind.

A *deck-tackle* is a heavy double purchase used in heavy work about decks.

A *fish-tackle* is a heavy double purchase used to fish the anchor.

A *fore and aft-tackle* is any tackle used in the direction of the length of the vessel, such as that used to stretch the backbone of an awning.

A *griolet-purchase* consists of two tackles, called muzzle-purchase and breech-purchase, and is used in dismounting guns on lower decks. The purchases are threefold.

A *hatch-tackle* is a common luff-purchase, used generally for hoisting articles from below.

A *jeer-tackle*, or *jeers*, is a purchase used in sending up and down lower yards. The upper block is often connected with and made to form part of the yard slings, the chain being attached to the block by a slip link. The block is thus always in place, and time is saved when it is required for use.

Jiggers are small luffs used for various purposes.

Rigging-luffs used in setting up rigging have two single blocks.

A *pendant-tackle* is composed of a double and single block. It is hooked to the mast-head pendants, and is used in staying the masts and for other purpose.

A *reef-tackle* is used in reefing to rouse up the leeches of the courses and top-sails.

Relieving-tackles are hooked to the tiller in order to relieve the wheel ropes in heavy weather, or to steer the ship when the wheel-*ropes* are carried away. Generally a double and single block.

Rolling-tackles hook to the quarters of the yards and to the mas s, to steady the yards when the vessel is rolling heavily.

Rudder-tackles hook to the rudder-chains to steer the ship in case of accident to the rudder-head.

A *runner and tackle* is a tackle attached to a runner. They are used in staying masts.

A *sail-tackle* is the purchase used in sending up a topsail for bending.

A *side-tackle* is a double and single, or two double blocks. It is used in running out a broadside gun.

Stay-tackles are heavy double purchases which hook to the triatic stay in hoisting out heavy boats, etc. In provisioning ship, the yard and stay-tackles are used, and the stay-tackle hooks to the eye of a pendant from the lower cap stopped out to the main-stay.

A *Spanish-burton* is a purchase much used in the merchant service for handling cargo.

The *single Spanish-burton* has two single blocks. The standing part of the rope is spliced to the strap of the lower or movable block, and leads through the upper or stationary block; the hook for the weight is seized or bent to the bight, while the hauling part leads through the movable block. This increases the power three times.

The *double Spanish-burton* has one double and two single blocks; the standing part spliced to the strap of one single block, then rove through the double or stationary block, and the bight seized to the strap of the lower block, to which the weight is hooked The end is then rove up through the double block, through the lower block, and finally through the block to which the standing part is made fast. This purchase increases the applied power five times.

A *stock and bill-tackle* is a small tackle used when securing an anchor for sea.

A *top-burton* is a tackle of sufficient length for the lower block and end of the fall to reach the deck when the upper block is hooked to the eye of a pendant at the topmast-head. It has the purchase of a luff-tackle, or a double and single block. A fiddle-block is used in place of the double block, on account of the narrow space under the eyes of the topmast rigging.

A *top-tackle* is a double purchase used in sending a topmast up or down.

A *train-tackle* consists of a double and single, or two double blocks. It is hooked to the rear of a gun-carriage, and to an eye-bolt in the deck, and is used for running in a broadside gun, or to prevent it from running out while loading.

Tricing-lines are single whips, or sometimes gun-tackle purchases, used to trice up the studding-sail booms.

Watch-tackle.—A common luff-purchase, or jigger fitted with tails.

A *winding-tackle* is a purchase of a double and single or two double blocks. It is used in hoisting heavy weights, being hooked to the eye of a top-pendant stopped out to the lower yard-arm. The pendant is generally rove through a block at the masthead, and secured to the deck near the mast.

Yard-tackles are heavy tackles used on the lower yards, in connection with the stay-tackles in hoisting heavy weights. The upper block is usually fitted with a strap for passing round the yard.

Besides the tackles enumerated, there are various whips and jiggers in general use on board ship, such as *water-whips*, *boom-jiggers*, *bunt-jiggers*, *clew-jiggers*, *lift-jiggers*, *etc.*, *geer tricing-lines*, *tripping-lines*, *etc.*

Remarks.—The swallow of a block should be, generally, one-tenth inch for every quarter-inch in circumference of the fall.

Manila-falls offer less resistance by friction than tarred hemp-falls.

Whenever great weights are to be moved, it is best to hitch the standing part of the fall around the neck of the strap, in place of securing it to the becket.

Hooks should be thick in the bend, and, when subject to much strain, should have a good *mousing* to counteract the tendency to straighten out or to become unhooked.

In *racking* a purchase-fall, the hauling part should be racked to the part leading from the opposite side of the block.

In lowering, the *standing part* experiences the strain which the hauling part experiences in hoisting.

The strap of the upper block of a purchase should have *four* times *the strength* of the fall rove.

ROPE.

ROPE is principally made from hemp, manila, hide, or wire.

Flax is used for making sail-twine, and sometimes for deep sea sounding-lines.

The higher grades of hemp rope are made from Russian hemp, and all small stuff is hand-spun from American hemp.

Hemp rope untarred is called *white rope*, and is much used for lead and log-lines.

MANILA ROPE is more pliable, buoyant, and causes less friction than hemp rope. It is much preferred in this country for running rigging, hawsers, and tow-lines.

It is not tarred like hemp rope, but the fibres before being worked up are sprinkled with whale oil. In the case of large hawsers, the outside yarns of the strands are passed through the tar trough.

Whale-lines are made of selected manila, $1\frac{12}{16}$ to $1\frac{14}{16}$ inch in circumference, and are required to withstand a test strain of 6,000 pounds.

HIDE ROPE is made of strips cut from green hides. It is generally protected by grease and Swedish tar; or, in the case of wheel-ropes, by a coating of neat's-foot oil. It is used for tailing on to any ropes which are exposed to much chafing in one part, such as topsail-sheets and tyes, yard-ropes, etc.

The splices of hide rope should not be served.

WIRE ROPE is used wherever strength and durability, rather than flexibility, are required. It is made from steel or iron wire. Steel wire is about fifty-six per cent. stronger than corresponding iron wire. Both steel and iron wire may be galvanized without loss of strength.

SMALL STUFF is the general term for small rope, and the number of yarns is sometimes specified, as 24, 21, 18, 15, and 12-thread *ratline-stuff;* 9, 6, and 4-thread *seizing-stuff.*

Spun-yarn is made of *long tow*, laid up loosely left-handed, and is well tarred and rubbed down. It is known as 2, 3, 4, etc., yarn spun-yarn.

Hambroline is a fine description of seizing-stuff.

Round-line is made of three left-handed yarns, and is therefore right-handed.

18

House-line is left-handed, and is made of three yarns.

Marline is left-handed, and is made of two threads of finely dressed hemp.

All small stuff, except ratline-stuff, is measured by the pound.

Nettles are made by laying up two or three yarns neatly, and rubbing down smooth.

Foxes are made of two or more yarns, laid up by twisting.

A Spanish fox is a single yarn, twisted tightly in a direction contray to its natural lay. It is used for small seizings.

In the manufacture of rope, the fibres of hemp or manila are overlapped together, and compressed by twisting, to form the required size of thread or yarn. Yarns are then combined by laying up, and form a *strand;* three or four strands, by laying up, form a rope; and three or four ropes a cable.

The general rule is to spin the yarn from right to left, making the rope yarn *right-handed.* The strand formed by a combination of yarns becomes *left-handed.* Three of these strands being laid up together, form a right-handed or *plain-laid* rope. When three such ropes are laid up together, it forms a *left-handed* cable of nine strands, called *cable-laid* rope.

Cable-laid stay consists of twelve strands; or four plain-laid ropes, laid up as above, to form a single rope.

Shroud-laid rope is made by laying up four strands together, right-handed, around a heart of pliable rope to fill the vacant space in the centre.

A four-stranded rope is about one-fifth weaker than a three-stranded one in the smaller sizes; but the larger sizes are considered fully equal to plain-laid rope in strength.

The lanyards of lower rigging are made of four-stranded rope.

HAWSERS.—The largest hawsers are from eleven to twelve inches in circumference, and from that they decrease in size to four inch tow-lines. All manila hawsers should be plain-laid, and all over five inches should be four-stranded.

Remarks on Rope.—Rope contracts considerably by wetting. Advantage is often taken of this by wetting temporary lashings which are required to be very taut. In rainy weather, braces, halliards, sheets, and other running-rigging, must be slacked up to avoid *carrying away* something.

Rope should be thoroughly dried before being stowed away.

The size of a rope is denoted by its circumference, and the length is measured by the fathom. Right-handed ropes are coiled down *with the sun*; left-handed ropes *against the sun*. Left-handed cables and hawsers however are coiled away in the tiers with the sun.

In taking out new rope from a coil, the end should be passed through the coil and coiled down against its lay to clear it of turns.

The strength of a yarn may be called in round numbers one hundred pounds.

Two men can worm and serve seven fathoms of three inch rope in an hour; or worm, parcel, and serve three fathoms of seven inch in an hour.

Rules for finding the Breaking Strain of Rope of Government Make.

Untarred Hemp Rope.—Square of circumference in inches, multiplied by 1371.4=strength in pounds.

Tarred Hemp Rope.—Square of circumference in inches, multiplied by 1044.9=strength in pounds.

Manila Rope.—Square of circumference in inches, multiplied by 783.7=strength in pounds.

Iron-Wire Rope.—Weight in pounds per fathom, multiplied by 4480 =strength in pounds.

Steel-Wire Rope.—Weight in pounds per fathom, multiplied by 7098 =strength in pounds.

Practical Rules.

Rule for Ascertaining the Strength of Plain-Laid Rope.—Square the circumference, and divide by 3 for the breaking strain in tons, and by 6 for the working strain.

Rule for Calculating the Weight of Rope (Tarred Hemp).—Multiply the square of the circumference by the length in fathoms, and divide by 4.24 for the weight in pounds. The divisor for hempen cables is 4.79.

Rule for Finding the Weight a Rope will Lift when Rove as a Tackle.—Multiply the weight the rope will sustain by the number of parts at the movable block, and subtract one-fourth of this for resistance.

Rule for Finding the Size of Rope, when Rove as a Tackle, to Lift a Given Weight.—Divide the weight to be raised by the number of parts at the movable block, to get the strain on a single part; add one-third of this for the increased strain due to friction and reeve the rope of corresponding strength.

Rule for Finding what Number of Parts of a Small Rope are Equal to a Large Rope.—Divide the square of the circumference of the larger rope by the square of the circumference of the smaller, and the result will be the number of parts of the smaller equal to the larger.

To Determine the Relative Strength of Chain and Rope.—Consider the proportional strength to be ten to one, using the diameter of the chain and the circumference of the rope.

To replace five-inch rope use half-inch chain.

To Determine the Proportionate Strength of Wire and Hemp Ropes.—Multiply the square of the circumference of a hemp rope by the decimal .223 for iron wire, and by .12 for steel wire, and extract the square root of the product; the result will be the circumference of a wire rope of corresponding strength.

By multiplying the square of the circumference of a wire rope by 4.5 for iron wire, and by 8.4 for steel wire, and extracting the square root of the product, the circumference of a hemp rope of corresponding strength may be obtained.

N.B.—*The wire rope referred to has a hemp-heart.*

WIRE-RIGGING.

WIRE ROPE of a superior quality is made at the Navy Yard, Boston. It is six-stranded right-hand rope, and has a hemp-heart.

To splice wire.—Stick once whole strand, once two-thirds strand, and once one-third strand; get it on a stretch, break off the wires close to the rope by working them quickly backward and forward, and finally parcel and serve.

Always serve over the required length for an eye before splicing it

Cutting and Fitting, etc.

In cutting and fitting wire, it should be remembered that the neat length is required.

Wire stays and shrouds are parcelled and served for the entire length.

Wire is always cut on the straight.

Having secured one end, clap a tackle on the rope beyond the mark for cutting, on both sides of which put a good whipping. Lay an axe under the rope at the mark and beat it down with a maul.

In cutting shrouds, secure one end, lead the rope through a snatch-block lashed at a point from the end equal to the length of a shroud-leg, bring the other part back, and clap on a tackle as before. When both parts are straight, cut at the marks, having previously put on the whippings.

In cutting stays, the half-collar and sufficient end for splicing must be allowed for. The lashing eyes of stays are always spliced.

To Fit Wire-Rigging.—Stretch the rope, give it a good coating of red-lead and boiled-oil, worm, and parcel; coat the parcelling also with read-lead paint, somewhat thinner than before. Allow the rigging to stand about twenty-four hours, and finally serve with round-line.

The eye of wire-shrouds is made five square, and has a seizing similar to that of a hemp-shroud. All wire-rigging is set up with hemp-lanyards and patent dead-eyes.

To form the collar of wire-stays: open the rope into two legs of three strands each, a little over the length of the collar, cut an additional piece of rope of the same length as the opened legs, and from it take four strands, two for each leg. These are laid up in the vacant lays, making each leg five-stranded, and the ends are stuck at the crotch; a lashing-eye is spliced into the end of each leg.

Thimbles may be spliced in wire-rope as follows: red-lead, parcel, and serve the ropes the length of the round of thimble. Break the rope around the thimble and secure it in a bench-screw; stop the parts together, and pass seizings through the thimble and around the rope on each quarter; open out and splice, passing each wire separately.

Comparative Dimensions of Chain Cables, Hemp Rope, Iron and Steel Rope, their Weight per Fathom, and Breaking-strain.

Breaking-strain of wire and hemp ropes.	Approximate size of chains corresponding thereto.	Circumference.			Weight per fathom.					Size of wire used in rope (iron and steel).		Remarks.
		Hemp rope.	Iron-wire rope.	Steel-wire rope.	Chain as weighed at Washington Navy Yard.	Hemp rope tarred.	Hemp rope not tarred.	Iron-wire rope.	Steel-wire rope.	Circumference of rope.	Number of wire.	
LBS.	IN.	IN.	IN.	IN.	LBS.	LBS.	LBS.	LBS.	LBS.	IN.	B.W.G.	
4,880	5/16	2½	1¼	⅞	5.18	1.48	1.25	1.28	—	1¼	22	Steel and iron-
7,040	5/16 full	3	1½	1 1/16	—	2.12	1.77	1.72	—	1½	21	wire rope, in ac-
8,260	3/8 scant	3⅛	1⅝	1⅛	—	2.46	1.87	2.12	—	1⅝	21 full	cordance with
9,580	3/8	3¼	1¾	1¼	7.70	2.66	2.03	2.49	1.29	1¾	20	this table, have
11,000	3/8 full	3½	1⅞	1⅜	—	2.76	2.30	3.06	1.60	1⅞	20 full	a hemp-heart.
12,520	7/16	4	2	1½	11.11	3.72	3.09	3.22	1.74	2	19	The sizes of the
14,130	7/16 full	4½	2⅛	1⅝	—	4.67	3.89	3.65	2.14	2⅛	19 full	wire given are
15,840	1/2	4¾	2¼	1¾	14.08	5.69	4.33	4.15	2.51	2¼	18	those in use at
19,560	9/16	5¼	2½	1⅞	18.64	6.94	5.29	5.27	3.09	2½	18 full	the Government
23,660	5/8	5½	2¾	2	22.20	8.33	6.35	6.31	3.25	2¾	17	rope-walk at the
28,160	11/16	6½	3	2⅛	25.81	9.66	8.05	7.46	3.68	3	16	Navy Yard, Bos-
33,050	3/4	7¼	3¼	2¼	30.31	12.78	10.09	8.97	4.19	3¼	16 full	ton, Mass.
38,330	3/4 full	7¾	3½	2½	—	14.35	11.52	10.69	5.32	3½	15	No data for the
44,000	13/16	8	3¾	2⅝	37.73	14.65	12.21	12.72	5.97	3¾	14	weight of steel
50,060	7/8	8½	4	2¾	41.71	16.57	13.80	14.81	6.37	4	14 full	ropes smaller
56,520	15/16	9	4¼	3⅛	47.81	18.48	15.48	16.71	8.35	4¼	13	than 1¼ inch.
63,360	1	9½	4½	3¼	55.16	20.71	17.25	18.95	9.05	4½	13 full	Proof strains
70,580	1 1/16	10⅛	4¾	3⅜	66.44	25.83	19.68	21.40	10.02	4¾	12	to be as nearly as
78,220	1 1/8	11	5	3½	75.27	27.82	23.20	24.20	10.79	5	12 full	possible one-half
86,240	1 3/16	11¼	5¼	3¾	83.64	30.57	24.29	27.15	12.84	5¼	11	of the breaking-
94,650	1 3/16 full	11¾	5½	4	90.40	33.54	26.50	30.52	14.95	5½	11 full	strain.
103,450	1 1/4	12¼	5¾	4¼	—	36.40	28.80	33.95	16.87	5¾	10	In practice it
112,640	1 5/16	13½	6	4⅜	102.22	44.17	34.99	37.70	18.10	6	10 full	is advisable to
122,220	1 3/8	15	6¼	4½	112.27	54.72	43.20	41.65	19.13	6¼	9	take it at three-
132,200	1 7/16	15½	6½	4¾	120.84	58.27	46.12	45.90	21.61	6½	9 full	sevenths of the
142,560	1 7/16 full	16	6¾	5	126.69	61.84	49.15	52.50	24.44	6¾	8	average break-
153,320	1 1/2	16½	7	5¼	—	66.03	52.27	56.89	27.42	7	8 full	ing-strain.

GEO. E. TOWER,
Passed Ass't Engineer, U. S. N.

J. C. P. DE KRAFFT, Captain, U.S.N.
JAMES P. SPRAGUE, Chief Engineer, U.S.N.

NOTE. —Column 1 is not a standard of strength of cables. Column 2 is intended to give as nearly as possible the size of chains approximating in strength to certain given sizes of wire and hemp rope.

CABLES.

CHAIN CABLES for the naval service are made at the Washington Navy Yard.

The best iron is used; each bar is tested; and the links are carefully welded.

A cast-iron stud is inserted in each link, except those at the end of the sections. The object of the stud is to strengthen the link and keep the chain from kinking. The stud adds about one-fourth to the strength of the link, and, to compensate for the absence of studs, the end links are made of the same diameter as the cable next in size.

Chain cables are generally 120 fathoms long. A shackle is introduced (*rounded part forward*) at each section of 15 fathoms, and a swivel at 7½, 37½, and 82½ fathoms.

All cables are marked at the shop in the following manner: Each shackle is marked across the eye with its number; the swivels and club-link are marked with the number of the chain, date, place, and the initials of the inspector. On the studs are cast the initials U. S. and W. N. Y.; also the size of the chain in figures.

Proof of Cables.

Size. IN.	Pounds strain single proof.	Size. IN.	Pounds strain single proof.
1	26,800	1¾	87,800
1⅛	34,600	1⅞	100,800
1¼	44,800	2	117,600
1⅜	56,000	2⅛	134,400
1½	66,600	2¼	147,800
1⅝	78,000		

Cables issued to the service are subjected to single proof only, but triplets are cut from the chain to be issued, which must withstand double the above proof before breaking.

ta Concerning Chain Cables, from Tests at the Washington Navy Yard during the Time of the Session of the Wire Board, from Iron Rolled by the Government, and from Iron received under the Standard Government Test for the same.

Diameter of chain-iron.	Average breaking-strain.	Weight per fathom.	Diameter of chain-iron.	Average breaking-strain.	Weight per fathom.
IN.	LBS.	LBS.	IN.	LBS.	LBS.
$\frac{1}{4}$	4,087	3.35	$1\frac{3}{16}$	89,844	83.64
$\frac{5}{16}$	6,343	5.18	$1\frac{1}{4}$	112,430	90.40
$\frac{3}{8}$	9,300	7.70	$1\frac{5}{16}$	120,000	102.22
$\frac{7}{16}$	12,620	11.11	$1\frac{3}{8}$	124,000	112.27
$\frac{1}{2}$	16,550	14.08	$1\frac{7}{16}$	136,750	120.84
$\frac{9}{16}$	21,100	18.64	$1\frac{1}{2}$	157,750	130.69
$\frac{5}{8}$	26,100	22.20	$1\frac{9}{16}$	164,871	144.59
$\frac{11}{16}$	31,660	25.81	$1\frac{5}{8}$	171,600	154.30
$\frac{3}{4}$	37,580	30.31	$1\frac{11}{16}$	177,500	167.16
$\frac{13}{16}$	44,130	37.73	$1\frac{3}{4}$	217,840	176.98
$\frac{7}{8}$	51,090	41.71	$1\frac{13}{16}$	224,000	189.75
$\frac{15}{16}$	58,480	47.81	$1\frac{15}{16}$	239,874	223.47
1	67,000	55.16	2	255,600	234.48
$1\frac{1}{16}$	71,990	66.44	$2\frac{1}{8}$	288,548	263.40
$1\frac{1}{8}$	81,000	75.27			

Rule to Determine the Size of Chain Cable Corresponding to an Anchor of a Given Weight (Inclusive of Stock).

Cut off the two right-hand figures of the number of pounds of the anchor's weight, and multiply the square root of the remaining quantity by 4; the result will be the diameter of the chain in sixteenths of inches. Thus:

Weight of anchor in pounds	5,000
Cut off two right-hand ciphers, leaves	50
Square root of 50	7.071

$7.071 \times 4 = 28.284$ and $\frac{28}{16} = 1\frac{12}{16}$, the diameter of chain needed.

Wire Cables.

Wire cables are being introduced into many English and German vessels, and the British Lloyd's have sanctioned the use of one flexible steel wire cable for steam vessels.

The principal advantage claimed for the use of wire cable over chain cable is uniformity of strength. Chain cables frequently have defective welds, but a wire cable is composed of many threads, and these completely "break joint" with each other, and thus neutralize any defect in the wires.

There is also a great saving in weight. A chain cable with two inches thickness in each link weighs about 235 lbs. per fathom; while steel wire cable of superior strength weighs only about 40 lbs. per fathom, thus saving nearly 200 lbs. per fathom used, or many tons in a full length of cable. It is true that the weight of the chain cable greatly assists the anchor in holding the vessel, but the comparatively light wire cable may be attached to a suitable anchor of increased dimensions, and the greater facility of handling the wire must be of importance, especially as regards the time necessary to weigh anchor.

There is no noise in working the wire cable and it may be stowed upon a reel on deck, thus avoiding the stowage in chain-lockers, forward, of a weight of chain which tends to strain the vessel at that unsupported part.

Wire cable has been in use on H.B.M. Ships Valorous and Eclipse, and also on board some of the Channel steamers, for some time.

The appliances for working it on board one of these vessels are as follows: The wire is fitted on the port side, and is 150 fathoms long, 5 inches in circumference, and weighs 28½ cwt., with a breaking strain of 65 tons. An ordinary chain cable is fitted on the starboard side, and the lower part of the capstan is reserved for working this cable, while the upper part, and a sister-capstan, placed just forward of it, works the wire, which is passed around them in grooves in the form of a figure 8; this avoids surging, as the rope leads on to the lowest ring on the main-capstan and leads off the top ring of the sister-capstan, and to prevent chafe the grooves are set some distance apart. The wire cable stows on a reel conveniently placed abaft the capstans on the same deck. Automatic nippers secure the cable by friction while the ship is anchored, one being

placed where the port riding-bitt would stand, and the other in the eyes of the ship.

When the anchor is let go, the cable runs straight from the reel to the nippers and through the hawse-holes.

ANCHORS.

ANCHORS are of two kinds—*Solid* and *Portable*.

Solid anchors are those which have the shank and arms wrought into one mass.

Portable anchors are those which admit of being separated or taken to pieces, and in many of which the arms are movable.

The anchor known as Trotman's anchor is in general use in the merchant service. All anchors used in the navy are made at the Washington Navy Yard.

The navy anchor consists of the following parts: *shank*, *ring* (or shackle), *arm*, *palm* (or fluke), *bill* (or point), *blade*, *crown*, *stock*, and *throat*.

The *shank* is the main body of the anchor. The ring is bolted to the upper end, and the arms are welded to the other. The crown is the heavy end of the shank, where the arms are welded. The *stock* is the iron beam at right angles to the shank. It has a shoulder near its middle, and when this shoulder is against the shank it is keyed on the other side. The end opposite the shoulder is bent for convenience in stowage. On the ends of the stock are cast-iron balls, the one on the bent end being movable.

The *arm* consists of the *palm*, the *bill*, and the *blade*. The palm is shield-shaped, and is welded and riveted to the *blade*.

The *bill* is the part of the arm which projects beyond the palm.

Bower and sheet-anchors for the navy are alike in weight. All anchors and kedges have iron-stocks.

The weight of an anchor, *as marked on it*, is exclusive of the stock, but inclusive of the bending-shackles.

The weight of an iron-stock is nearly one-fourth of the anchor to which it belongs.

Stream-anchors are about one-fourth the weight of the bower.

Kedges, when four are allowed, are respectively one-seventh, one-eighth, one-tenth, and one-fourteenth the weight of the bower; when three are allowed, one-sixth, one-eighth, and one-tenth; when two

are allowed, one-sixth and one-tenth; and when one is allowed, one-eighth.

To determine the weight of a bower or sheet-anchor for a vessel, multiply her displacement in tons by the number assigned to her approximate displacement in the following table, in the column headed "multipliers," and the product will express the number of pounds, *inclusive of stock.*

Each boat of every vessel is allowed one anchor; the weight in pounds to be obtained by multiplying the square of the extreme breadth by 1.2.

Size of vessel.	Multipliers.	Bower.	Sheet.	Stream.	Kedges.
Over 3,700 tons displacement...........	1¾	2	2	1	4
" 2,400 " "	2	2	2	1	3
" 1,900 " "	2¼	2	1	1	3
" 1,500 " "	2½	2	1	1	3
" 900 " "	2¾	2	1	1	3
Under 900 " "	3	2	1	1	2
Double-turret monitors	1	2	1	—	2
Single-turret monitors.................	1	2	—	—	2

The following proportions of parts is an average of those in use:

Length of shank, 100; length of stock, 100; length of arm, 40; radius for describing curve of arms, 35; angle of face of palm with shank 51°.

With such proportions, the angle of shank with the ground is 24°, and that of the blade 75°.

Mushroom-anchors, used for moorings, have the head shaped like a bowl, and require no stock.

Ice-anchors are formed of a bar of round iron bent in the form of a pot-hook; a hole is cut in the ice and the point inserted; the riding-hawser is bent to the other hook.

A Sea Anchor.—This anchor may frequently be of the greatest possible use, and may be made in the following manner: Take three spare spars (top-gallant studding-sail booms will be sufficiently large), with these form a triangle the size you think will be large enough, when under water, *to hold the ship*; cut these spars to the required

length before or after cross-lashing them well at each angle; then make fast your spans, one to each angle, so that they will bear an equal strain when in the water; but should your spars be weak, you should always increase the number of spans accordingly; fill up the centre of the triangle with strong canvas, having eyelet-holes round its sides, about three inches apart, to which eyelet-holes attach the canvas securely to the spars; at the back of the canvas pass many turns of inch or inch and a half rope, net fashion. A proper net would be preferable to rope so expended. To the base of the triangle attach a weight or small anchor, supported in the centre of the base by a span running from each of the lower angles. To the first-mentioned span make fast the stream cable. When everything is quite ready, hoist or put it overboard from the place you think it will answer best. There is every reason to believe that with this anchor under the trough of the sea, and seventy or eighty fathoms of stream cable out, that a ship's drift would not be very great.

A triangular form is used in order that the sea may strike lightly on the part near the surface.

SAILS.

THE material in general use for sails is canvas made of flax, hemp, or cotton. The coarser and heavier qualities are used in the large sails, where great strength is required, while the light sails, intended for use only with moderate winds, are made of the finer qualities of canvas.

Flax Canvas.—Flax canvas for the Navy is twenty inches wide, and each bolt contains forty yards. The blue thread is one and five-eighth inch from selvage in Nos 1 to 5 inclusive, and one inch in Nos. 6 to 9 inclusive. The warp and filling of Nos. 1, 2, 3, 4, and 5 is of double thread; No. 6, double warp and single filling; and Nos. 7, 8, and 9, single warp and filling. The warp is rather more twisted than the filling.

Cotton Canvas.—Cotton canvas is twenty-two inches wide, and each bolt contains fifty running yards.

The blue thread is one and one-half inch from selvage in Nos. 1, 2, and 3; one and one-fourth inch in Nos. 4, 5, and 6; and three-fourths inch in Nos. 9 and 10. The filling is stronger than the warp.

Hammock and bag-stuff is forty-two inches wide; cot-stuff is thirty inches wide. The bolts contain fifty running yards.

All raven's duck has thirty-five yards to the bolt; width twenty-eight inches.

The breadths of canvas, cut to the required length, are sewed with a flat double seam, using flax or cotton twine according to the material of which the canvas is composed. The edges of sails are finished with a broad hem called the *tabling*, and to this is sewed the bolt-rope, by which the sail is rendered capable of withstanding the required strain.

Sails are divided into two general classes—square, and fore-and-aft. The former are not necessarily rectangular. The principal square sails are called the courses, top-sails, top-gallant sails, and royals.

They are also named from the mast to which they pertain, as the main-course or main-sail, fore top-sail, mizzen top-gallant sail, etc.

The upper and lower edges are called the *head* and *foot*, and the sides are called *leeches*. The roping of these different parts is also known as *head-rope*, *foot rope*, and *leech-ropes*. The sails are bent to the yards by means of yarn *robans* passed through eyelet-holes made in each seam at the head of the sail, and secured to a jack-stay on the yard. At each upper corner, loops called *head-cringles* are worked, through which small ropes called *head-earings* are passed, and by which they are made fast to the yard. The lower corners are called *clews*, and in large sails are fitted with *clew-irons*, to which the tacks, sheets, and clew-lines, are hooked.

Reef-bands are strips of canvas sewed across the sail parallel to the head.

Reef-points are short pieces of rope rove through eyelet-holes at every seam in the reef-band, and serve to secure the reef-band to the yard when the sail is reefed. In the case of four reef-bands, the first is called *single reef*, second, *double reef*, third, *treble reef*, and fourth, *close reef*.

Fore-and-aft sails are bent to the gaffs or masts, or are hoisted upon the stays. In a square-rigged vessel, fore-and-aft sails are also carried.

Those which are bent to the gaffs at the fore and main-masts are called *try-sails*, and that at the mizzen-mast is called the *spanker*. The try-sails and spanker are taken in by means of *brails* on board men-of-war.

All jibs and *stay-sails* are bent to *hanks*, or lacings traversing on

Table of Sails Allowed

Sails.	Over 4,000 tons displacement.					Over 3,000 tons displacement.					Over 2,000 tons displacement.				
	No. of sails.	No. of canvas.	Size of rope.			No. of sails.	No. of canvas.	Size of rope.			No. of sails.	No. of canvas.	Size of rope.		
			Head.	Foot.	Leech.			Head.	Foot.	Leech.			Head.	Foot.	Leech.
Fore-sails	2	2	2¾	5½	5½	2	2*	2¼	5	5	2	2	2¼	4¼	4¼
Fore top-sails	2	2	2¾	5½	4¼	2	2*	2¼	5	3¾	2	3	2½	4¼	3¼
Fore top-gallant sails	1	5	2	3½	2½	1	6	1¾	3¼	2¼	1	7	1¾	3	2¼
Fore-royals	1	8	1½	2	2	1	8	1½	2	2	1	8	1½	1¾	1½
Main-sails	1	2	2¾	5	5	2	3	2½	4½	4½	2	3	2¼	3¾	3¾
Main top-sails	2	2*	2¾	5½	4½	2	2	2½	5¼	4¼	2	2	2½	4¼	3½
Main top-gallant sails	2	5	2	3½	2½	2	5	1¾	3¼	2¼	2	6	1¾	3	2¼
Main-royals	1	8	1½	2	2	1	8	1½	2	2	1	8	1¼	2	1¾
Mizzen top-sails	2	3	2½	4½	3¼	2	3	2¼	4¼	3	2	4	2	4	3
Mizzen top-gallant sails	1	7	1½	2½	2	1	7	1¼	2¼	2	1	7	1	2¼	1¾
Mizzen-royals	1	8	1¼	2	2	1	8	1¼	1¾	1¾	1	8	1	1¾	1½
Flying-jibs	1	6	—	2½	2½	1	7	—	2	2	1	7	—	2	2
Standing-jibs	2	3	—	3¼	3½	2	4	—	2½	3	2	4	—	2½	3
Fore try-sail	1	2	2¼	3¼	3½	1	2	—	2¾	2¾	1	2	1¾	2¾	2¾
Main try-sails	1	2	2¼	3½	3½	1	2	—	2¾	2¾	1	2	1¾	2¾	2¾
Storm-mizzen	1	2	2	3	3	1	2	—	2½	2½	1	3	1½	2½	2½
Spankers	2	3	2¼	2¾	3¼	2	3	—	2	2¾	2	4	1½	2¼	2¾
Fore storm stay-sail	1	1	—	3½	3½	1	1	—	3	3	1	2	—	3	3
Fore top-mast stay-sail	2	2	—	3½	3½	2	2	—	3¼	3¼	2	2	—	3	3
Mizzen storm stay-sail	1	1	—	3¾	3¾	1	1	—	3¼	3¼	1	2	—	3¼	3¼

The above table supposes the vessel to be ship-rigged. Steamers as an occasional auxiliary, one complete suit of the sails they are in-

* One fore-sail, one fore and one main top-sail will be of No. 1 canvas.

to Naval Vessels.

Over 1,000 tons displacement.					Under 1,000 tons displacement.				
		Size of rope.					Size of rope.		
No. of sails.	No. of canvas.	Head.	Foot.	Leech.	No. of sails.	No. of canvas.	Head.	Foot.	Leech.
2	2	2	4	4	2	2	2	4	4
2	3	2	4	4	2	3	2	4	3
1	7	1½	2¼	2¼	1	7	1½	2½	2
1	8	1¼	1½	1½	1	8	1	1¼	1½
1	3	2¼	3¼	3¼	1	4	2	3¼	3¼
2	2	2¼	4	3	2	2	2¼	4	3
2	6	1½	2¾	2	2	6	1½	2½	2
1	8	1¼	2	1¾	1	8	1¼	2	1½
1	4	2	3¾	2¾	1	4	1¾	3½	2¾
1	7	1	2	1½	1	7	1	2	1½
1	8	1	1¾	1¼	1	8	1	1¾	1¼
1	7	—	2	2	1	7	—	2	2
2	4	—	2¼	3	2	5	—	2	2½
1	2	1½	2½	2½	1	2	1½	2¼	2¼
1	2	1½	2½	2½	1	2	1½	2¼	2¼
1	3	1½	2¼	2¼	1	3	1½	2	2
2	4	1¾	2	2½	2	5	1¾	2	2¼
1	2	—	3	3	1	3	—	3	3
2	2	—	3	3	2	3	—	3	3
1	2	—	3	3	1	3	—	3	3

Remarks.

All fore-and-aft sails running upon stays are to be bent with composition or galvanized-iron hanks.

Top-sails to be fitted with French reefs, but the close reefs with points.

All fore-and-aft sails, as well as courses, top-sails, and top-gallant sails, to be finished with composition or galvanized-iron clews. The latter should be covered with leather, as well as other places liable to heavy chafe.

All boats' sails to be made of cotton duck, quite light.

Gaff top-sails to be furnished the vessels requiring them.

Blocks in the head of sails to be fitted with patent rollers.

fitted to spread but a small proportion of canvas, or to resort to it
tended to spread, and duplicates only of those likely to be used.

the stays. They are hoisted by *halliards*, hauled down by *down-hauls*, and trimmed aft by the *sheets*. The jibs, fore stay-sail, and fore top-mast stay-sail, are set upon the stays which support the fore-mast, and are termed the *head-sails*. They are triangular in shape, but the stay-sails which set between the masts are generally quadrilateral, and take their names from the stays on which they set.

The lower corner of fore-and-aft sails is called the *tack*, and the same term is applied to the weather-clew of a course. The edge of a fore-and-aft sail which lies along the stay or mast is termed the *luff*, the after edge is known as the *leech*, and the lower edge as the *foot*.

A gaff top sail is generally triangular in shape, and is set between the topmast and the gaff.

The lower sails of fore-and-aft rigged vessels are named from the mast on which they are set.

The depth of a *course* from the head to the foot is termed the *drop*. The same dimension of other square sails is called the *hoist*.

At each end of the reef-bands, cringles are worked and iron thimbles inserted.

Reef-earings are used in securing these reef-cringles to the yards when the sail is reefed.

The ropes and tackles used in handling these sails are known as *halliards*, by which they are hoisted; *sheets*, by which the clews are extended; *clew-lines* and *clew-jiggers*, *bunt-lines*, *bunt-jiggers*, and *leech-lines*, which are used in reducing sail; *bowlines*, which steady the leeches when close to the wind; *braces*, by which the yards are moved; and *reef-tackles*, which assist in reefing the sails.

Storm sails are made of the strongest canvas, and are used only in the heaviest weather. In large vessels the principal storm sails are the storm mizzen and fore and main storm stay-sails. The try-sails are also used in bad weather and frequently take the place of storm stay-sails. These sails are used when "lying to."

When on a wind, *ships* are said to have their starboard or port tacks aboard, according to the side presented to the wind; but *fore-and-afters* are said to have their port or starboard sheets aft.

The altitude of sails set by halliards is called the *hoist*, but in the case of the courses the same idea is conveyed by the term *drop*.

Sails should sit as nearly flat as possible. In American pilot-boats and yachts the sails are set as flat as boards, and laced down to spars or booms. The superiority of this plan was exemplified in the

famous race between the yacht America and the English Yacht Squadron. While there was not much difference while going free, the America distanced all her competitors as soon as hauled up to make a stretch to windward.

Cutting Out Sails.

The draft of the ship and spars is of great service to the sail-maker, as by it he can measure for and cut out the sails. In cutting out, it is a primary object to cut the various gores so that, when brought together, the form required will be produced, with the least possible waste of canvas. This is done by casting the number of inches contained in each gore, so that when put together the sum shall be equal to the number contained in the after leech-cloth of a fore-and-aft sail.

The same practice obtains in square sails. Sails are cut out, cloth by cloth, according to the number of cloths the width requires, allowing for seams, tabling, and slack cloth.

In sails cut square on the head and foot, with gores on the leeches, the cloths on the head are cut square to the depth; and the gores on the leeches are found by dividing the depth of sail by the number of cloths gored. By drawing on paper the gored side of the sail, by a convenient scale of parts, the length of each gore may be exactly found.

The foot of square sails is *roached*, so as to avoid chafing by boats or stays in the line of their middle parts.

Sails have a double flat seam, and should be sewed with best twine of three threads, and have from one hundred and ten to one hundred and eighteen stitches in every yard of length.

All sails should be sewed quite home and well rubbed down afterward. The twine is waxed with beeswax mixed with one-sixth part turpentine, and for small sails the beeswax may be mixed with an equal portion of hog's lard.

Boom main-sails and the spankers of ships have the seams broader at the foot than at the head.

The seams of heavy sails are usually $1\frac{1}{2}$ inches wide, and treble seamed down the middle of the seam; those of lighter sails are one inch wide.

One man can *sew one hundred* yards in ten hours, single seam.

The tablings are of a proportionate breadth to the sail, and sewed with about seventy-two stitches in a yard.

Sails are strengthened with additional canvas, called *linings*, in those places most exposed to strain or wear. Fore-and-aft sails are strengthened at the clews by *tack-pieces;* and jibs often have a *strain-band.*

Sails are usually supplied ready made, but require fitting with *points*, *earings*, *bow-line bridles*, *beckets*, and *robands.* Their edges are tabled. The tabling of large sails is reinforced at the clews and fort by a third fold of canvas sewn in. The tablings and clew-patches are placed on the *after* side of square sails, and on the *port* side of fore and aft sails.

Reef-Bands.—Courses have two reef-bands on the fore side, the first one-sixth the drop of the sail from the head, and the other the same distance below it. A belly-band is also placed half way between the lower reef and the foot.

Top-sails have four reef-bands, the lower of which is at half the depth of the sail. Small top-sails are often fitted with three bands. There is also a belly-band half the distance between the lower reef and the foot.

Top-gallant sails usually have one reef-band, though seldom used.

Spankers have usually two reef-bands, one running diagonally termed *balance-reef.*

The term balance-reef is also applied to the close-reef in fore-and-afters.

The jib has a reef-band, and sometimes a *bonnet*, which laces to the foot of the sail. The lug fore-sails of some schooners have bonnets also.

Roping on the leeches of square sails is sewn on with enough slack canvas to allow the rope to stretch.

In the leeches of fore-and-aft sails, a sufficient amount of slack rope is introduced to prevent the foot from curling up.

Spankers usually have an allowance for stretch of $3\frac{1}{2}$ inches to each yard of foot, $1\frac{1}{2}$ to each yard of head, and $2\frac{1}{2}$ in each yard of leech.

Sails are always bent with their roping next the yard or gaff, to avoid cutting the stitches by chafe. In square sails the roping is on *the after side; in* fore-and-aft sails usually on the port side. The *foot-roping is the* stoutest.

To Find the Number of Square Yards in Sails.

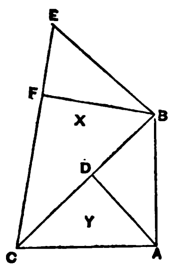
Head × Depth + Depth × ½ difference of Head and Foot.

EXAMPLE.

Head	=	43½ cloths	=	29 yards.
Foot	=	46 cloths	=	30½ yards.
Depth	=	12⅝ yards		

$$29 \times 12.66 = 367.14$$
$$12.66 \times .75 = 9.50$$

376.64 square yards.

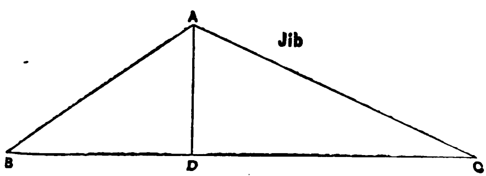


Trysail.

$$\frac{BC \times AD}{2} = Y.$$

$$\frac{EC \times BF}{2} = X.$$

$$\text{Area} = X + Y.$$



Jib

$$\text{Area} = \frac{BC \times AD}{2}$$

Table for Computing the Area of Sails.

LIST OF SAILS.	NO. OF YARDS IN EACH.	AREA IN SQUARE FEET.	TOTAL AREA.
Square Sails.			
Courses { Fore			
Courses { Main			
Top-sail { Fore			
Top-sail { Main			
Top-sail { Mizzen			
Top-gallant sails { Fore			
Top-gallant sails { Main			
Top-gallant sails { Mizzen			
Royals { Fore			
Royals { Main			
Royals { Mizzen			
	TOTAL AREA SQUARE SAILS.		
Fore-and-Aft Sails.			
Flying-jib			
Jib			
Fore top-mast stay-sail			
Fore try-sail			
Main try-sail			
Spanker			
Studding Sails.			
	TOTAL AREA WITH ALL SAIL.		

Deduction for Reefs.

For single reefs, deduct sq. feet.
" double " "
" treble " "
" close " "

PAINTING SHIP.*

WHITE-LEAD is the principal ingredient in all ordinary colors used in painting. The *quality* is, therefore, of the greatest importance. It is most difficult to get it free of adulteration. The cheap kinds are adulterated by "barytes," which renders it of a less compact body, and causes it to be much more easily acted upon by the atmosphere. White-lead improves by keeping. In mixing, the oil and the turpentine should be thoroughly incorporated with the white-lead. If patent dryers are used, the proportion is about half an ounce to a pound of color.

ZINC WHITE is more durable than white-lead; it is extremely pure, but possesses little body.

VEGETABLE BLACK.—This is the cheapest and best black for all ordinary work. In a dry state it resembles soot, and, being free from grit, does not require grinding. It should be mixed with boiled oil.

VERMILION, in a state of powder, may be tested by placing a dust of it on a sheet of clean white paper, and crushing it with the thumb-nail. If pure it will not change its color by any amount of rubbing; but if adulterated, it will become a deep chrome yellow, or assume the appearance of red-lead, with which article it is mixed in order to cheapen it. This accounts for the unstable quality of the inferior kinds of vermilion. When using vermilion, if necessary to give two coats, *both* should be of the best quality.

BLUE.—The most serviceable blue for the painter is French ultramarine. It is a permanent, kindly-working color, and affords a variety of clear tints when mixed with white. It is a brilliant blue, and preserves its purity when reduced in tone by the addition of white.

It may be deepened by Prussian blue or indigo, or by a trifling addition of vegetable black.

GREEN, like black, should be mixed with boiled oil, or boiled oil and varnish, and not with linseed-oil and turpentine.

---

* *Portions of these remarks* are extracted from The Sailor's Pocket-Book.

Mixing Colors.

CREAM COLOR.—Chrome yellow, the best Venetian red, and white-lead.

FAWN COLOR.—Burnt sienna, ground very fine, mixed with white-lead.

DRAB.—Raw or burnt umber and white-lead, with a little Venetian red.

PURPLE.—White-lead, Prussian blue, and vermilion.

VIOLET.—White-lead, French ultramarine, vermilion, and a small portion of black.

FRENCH GRAY.—White-lead and Prussian blue, tinged with vermilion.

SALMON COLOR.—White-lead, tinged with Venetian red.

IMITATION OF GOLD.—Mix white-lead, chrome yellow, and burnt sienna until the proper shade is obtained.

Proportions for Mixing Black Paint.

Black	28 lbs.
Linseed-oil, raw	¾ gallon.
Linseed-oil, boiled	¾ gallon.
Litharge	1½ lb., or patent dryers.
Total weight	43½ lbs. mixed color.

One pound of black paint will cover five square yards.

NOTE.—*A little salt added to black paint will prevent blistering.*

Proportions for Mixing White for Between Decks.

White-lead	28 lbs.
Patent dryers	1½ lbs., or liquid—½ pint.
Linseed-oil, raw	¾ gallon.
Turpentine	¼ gallon.
Total weight	38½ lbs. mixed color.

White for out-door work, as before, omitting one-fourth of the turpentine and substituting oil. One pound of white paint will cover four square yards. On new work one-third less is covered.

Stone Color.—Same proportions as the white; stained with burnt umber and spruce ochre; ground in oil to the tint required.

Mast Color.—Same proportions as out-door white; stained with spruce yellow ochre and a little Venetian red to the tint required.

Copper Color Paint.

(*A very good recipe.*)

Six parts of spruce ochre, one part Venetian red, and one part of black.

Bronze Paint.

Chrome green	2 lbs.
Ivory black	1 oz.
Chrome yellow	1 oz.
Good Japan	1 gill.

Grind altogether, and mix with linseed-oil.

Removing Old Paint.

Nothing is so efficacious as heat, applied by a small brazier with a handle.

One part of pearlash mixed with three parts of quick stone-lime, (by slaking the lime in water and then adding pearlash), laid over paint work, and allowed to stand 14 or 16 hours, will soften it so that it can be easily scraped off.

Gilding.

Books of gold-leaf contain twenty-five leaves. Gilders estimate their work by the number of "hundreds" it will take (meaning one hundred leaves) instead of the number of books.

Gold-leaf should fall freely from the book on the leaves being opened, without any particles sticking to the paper.

The simplest *way to use gold*-leaf is as follows: Procure a clean

sheet of silver or tissue-paper, of not too great a density, and rub it over lightly, on one side only, with a piece of white-wax—beeswax or wax-candle will do. The paper should be placed on something flat, so that the wax is spread evenly.

After waxing, a sheet of paper should be set into squares a little larger than the leaves of the book of gold, which should be opened, and the waxed-side of the tissue-paper gently pressed on the gold-leaf. On removing the paper, the gold-leaf will be found attached to it, and is ready for use. All that the gilder has to do is to cut it into convenient strips, and pressing it on the sized-surface, the gold will readily leave the paper. The work should be finished by gently dabbing it with a pad of cotton-wool.

Gilt work exposed to the weather lasts much longer if it receives a coat of clear varnish when finished.

SIZE.—Oil gold-size gives the best results, but requires time—twelve hours or so—before it gets "*tacky*" enough. Japanner's gold-size, on the other hand, dries very quickly, and is useful when pressed for time.

In estimating amount of gold-leaf required for gilding ordinary grooved-mouldings, round-boats, etc., remember that one leaf covers about nine inches.

USEFUL PRACTICAL RECIPES.

Paint for Tarpaulins.—Add twelve ounces of beeswax to one gallon of linseed-oil; boil it for two hours; prime the cloth with this mixture, and use it in place of boiled oil in mixing the paint.

To Kill Knots.—All knots should be killed before painting, otherwise the turpentine will exude. Cover them with fresh slaked lime for twenty-four hours; scrape lime off and lay on a coat of red and white-lead mixed with glue-size. Pumice-stone when dry, and lay on some paint.

Another.—One pint of vegetable naphtha, one teaspoonful of red-lead, quarter pint of japanner's gold-size, seven ounces of shellac. Add them together, set in a warm place to dissolve, and let the whole be frequently shaken. Coat the knots with it.

Distemper.—May be used instead of and looks better than white-wash. One hundred and twelve pounds whiting, twenty-eight pounds white-lead, and seven pounds glue, mixed with boiling water.

Putty.—Well dried and sifted Spanish whiting, fifty-six pounds, and one gallon linseed oil well mixed, left for three days, and then worked up again before using.

To fifty-six pounds of whiting add three pounds of glue boiled in half a gallon of water. A little alum added has a good effect in hardening.

To Make Size.—Parchment chippings make the best. Put them in an iron kettle, and fill with water; let it stand twenty-four hours; then boil for five hours, occasionally taking off the scum. Strain through a coarse cloth.

If the size is required to be kept any length of time, dissolve three ounces of alum in boiling water, and add to each bucketful. Then boil again till it becomes strong, and strain a second time.

Boiled Oil for Quick-drying purposes.—With two gallons of linseed-oil mix two pounds of litharge and one pound of red-lead. Keep it on the fire, allowing the heat to increase slowly; boil for three hours; then remove it from the fire, and let it stand twenty-four hours; take off the scum, and it will be ready for use.

Boiled Oil.—To sixteen gallons of oil when boiling, add one pound of red-lead and one pound of powdered litharge. Boil six hours. *Another:* Four and one-half gallons of raw oil, one pound of copperas, two pounds of litharge. Put the litharge and copperas in a cloth bag, and suspend in the kettle. Boil five hours over a slow fire, then let it stand.

Baked Oil.—Into an iron pot put half a gallon of linseed-oil, to which add half a pound of litharge; boil carefully; keep it simmering for twelve or fourteen hours, and if when a little cooled it will draw into a thread, the oil will be ready for use.

Black Varnish.—To asphaltum and spirits of turpentine, add a small portion of baked oil. *Another:* To baked oil dissolved in spirits of turpentine, add Frankfort black.

Black Japan Varnish.—Bitumen, two ounces; lamp-black, one ounce; Turkey umber, one-half ounce; acetate of lead, one-half ounce; Venice turpentine, half-pint; boiled oil, twelve ounces. Melt the turpentine and oil together, carefully stirring in the other ingredients previously powdered. Simmer all together for ten minutes.

Black Japan for Metals.—Burnt umber, four ounces; asphaltum, one and one-half ounce; boiled oil, two quarts; mix by heat, and thin with turpentine.

Vermilion Varnish.—Baked oil dissolved in spirits of turpentine, with vermilion added.

Lac Varnish.—Five parts of lac, one of turpentine, dissolved in five times its weight of alcohol; keep warm until fluid, then strain.

Spar Varnish.—Boiled oil and resin.

Cabinet-maker's Varnish.—Pale shellac, seventy parts; mastic, seven parts; strong alcohol, one hundred parts. Dissolve, and dilute with alcohol.

Cabinet Varnish.—Fused copal, fourteen pounds; hot linseed-oil, one gallon; hot turpentine, three gallons. Properly boiled, dries very quickly.

Cheap Oak Varnish.—Dissolve three and one-half pounds of pale resin in one gallon of oil of turpentine.

Common Varnish.—Dissolve one part of shellac in seven parts of alcohol.

Copal Varnish.—Copal, thirty parts; drying linseed-oil, thirteen to twenty-five parts; spirits of turpentine, fifty parts. Fuse the copal as quickly as possible; add the oil, previously heated to nearly boiling point, mix well, then cool a little and add the spirits of turpentine; again mix well, and cover up till cooled to about 130° F., then strain.

White Copal Varnish.—Copal, sixteen parts; melt and add hot linseed-oil, eight parts; spirits of turpentine, fifteen parts; color with the finest white-lead.

White Varnish.—Copal, eight ounces; camphor, one ounce; alcohol, of ninety-five per cent., one quart; dissolve, then add two ounces of mastic, one ounce Venice turpentine; again dissolve, and strain.

White Varnish for Range Tables, etc.—White resin and turpentine, dissolved in a close bottle placed in hot water on a stove. *Or:* Canada balsam, one ounce; spirits of turpentine, two ounces; mix them together. Before varnishing, the work should be sized.

Varnish for Painting on Glass.—Take one ounce of clear resin;

melt it in an iron vessel; when all is melted, let it cool a little, but not harden; then add turpentine, sufficient to keep it in a liquid state. When cold, use it with colors ground in oil.

Gold Varnish.—Turmeric, one drachm; gamboge, one drachm; oil of turpentine, one quart; shellac, five ounces; sandarach, five ounces; dragon's-blood, seven drachms; thin mastic varnish, eight ounces. Digest, with occasional shaking, for fourteen days in a warm place; set it aside to fine, and pour off the clear.

Mastic Varnish.—Gum-mastic, five pounds; spirits of turpentine, two gallons. Mix, with gentle heat, in a close vessel; then add pale turpentine varnish, three pints.

Varnish for Iron-work.—Dissolve, in two pounds of tar-oil, one-half pound asphaltum, and one-half pound powdered resin. Mix hot, and apply cold.

Varnish for Metals.—Dissolve one part of bruised copal in two parts of strong alcohol. It dries very quickly.

French Polish.—Five ounces of naphtha, one ounce of shellac, one drachm of myrrh, ten grains of isinglass, and six drachms of olive oil.

French Polishing.—Pour a little linseed-oil into one cup, and some polish into another; roll a piece of woollen rag into a bale, saturate it with polish, and cover with a piece of linen drawn tightly over it. Apply one drop of oil and one drop of polish to the surface of the pad, and it is ready for use. The work having been thoroughly smoothed, the polishing is commenced with free, circular strokes, applied with very slight pressure, and having care that each part receives an equal amount of polish. Finish off with a little spirits of wine applied on a clean rubber.

Oil Polish.—Dissolve resin in turpentine to about the consistency of treacle; add two pints of linseed-oil to one of resin and turpentine.

Staining.

Black Stain.—Quarter-pound logwood; six ounces green copperas; half a gallon vinegar. Lay on warm.

Another.—Boil half-pound logwood in two quarts water; add one ounce pearlash, half-ounce verdigris, and half-ounce copperas. Strain, put in half-pound rusty steel filings, and lay on warm.

Mahogany Color (*Dark*).—Boil together, in a gallon of water, half-pound of madder and two ounces of logwood. When the wood is dry, after having been washed over with the hot liquid, go over again with a solution of two drachms of pearlash in a quart of water.

Mahogany Color (*Light*).—Wash the surface with diluted nitrous acid, and when dry use the following: dragon's-blood, four ounces; soda, one ounce; spirits of wine, three pints. When well dissolved, strain.

Rosewood.—Boil eight ounces of logwood in three pints of water until it is reduced one-half. Apply boiling hot two or three times. The stain for the streaks is made from a solution of copperas and verdigris in a decoction of logwood.

Ebony.—Wash the wood with a solution of sulphate of iron; when dry apply a mixture of logwood and nutgalls; wipe with a sponge and polish with linseed-oil.

To Dye Bright Red.—Take two pounds of red Brazil dust, and four gallons water; put in veneers until well covered, boil for three hours, and allow it to cool; then throw in two ounces alum, one ounce nitric acid, and keep lukewarm until the mixture has struck through.

To Dye Yellow.—Take two pounds of the roots of barberry, reduced to dust, two gallons of water; and two ounces of turmeric. Put in as many veneers as the liquor will cover; boil for three hours, often turning them. When cool, add two ounces of nitric acid, to assist the dye in striking through.

To Color Light Woods.—Curly-veined birch and beech, regularly brushed with aquafortis, and dried by heat, look remarkably like mahogany.

Another method is to smear the surface with a strong solution of permanganate of potash. About five minutes will generally suffice. When the action is ended, the wood is carefully washed, allowed to dry, and afterward oiled and polished in the ordinary manner.

A strong solution of *nitric acid* will stain wood black. Dilute nitric acid will produce yellow on wood.

Black Gun Polish.—Four ounces resin, two ounces lamp-black, two ounces shellac, one quart linseed-oil. Boil fifty minutes; then

add three ounces beeswax, half pint of turpentine. For bronzed guns, omit the lamp-black.

Black Polish for Iron.—Coal-tar, one pint; lamp-black, one ounce; hellebore, half-ounce; beeswax, one ounce. The beeswax and hellebore to be dissolved in the turpentine; then add the lamp-black and tar. Mix, warm it well, and apply at once.

Lacquering.

Lacquer is put on in two ways, called cold lacquering and hot lacquering. By the former a little lacquer is laid evenly over the work with a camel-hair varnish brush; it is then heated for a minute or two to set the lacquer. By the second method the work is heated first, and the lacquer brushed quickly over it. The great difficulty is to determine the exact degree of heat, and this knowledge can only be obtained by experience.

To Make Lacquer.—Mix the ingredients, and let them stand in a warm place for two days, shaking them frequently until the gum is dissolved; then let them settle for two days, and pour off the clear liquor ready for use. Pulverized glass is sometimes used to carry off impurities.

To Prepare Brass for Lacquering.—Clean the surface of the work as well as possible, place it in aquafortis and water; leave it there some time, and then put it into hot sawdust, and shake about until thoroughly dry.

Brass Lacquer.—Seed-lac, dragon's-blood, annatto, and gamboge, of each four ounces; saffron, one ounce; spirits of wine, ten pints.

Another.—Methylated spirits of wine, one gallon; seed-lac, bruised, ten ounces; red sanders, half an ounce. Dissolve and strain.

Gold Lacquer for Brass not Dipped.—Alcohol, four gallons; turmeric, three pounds; gamboge, three ounces; gum-sandarach, seven pounds; shellac, two pounds; turpentine-varnish, one pint.

Gold Lacquer for Dipped Brass.—Alcohol, thirty-six ounces; seed-lac, six ounces; amber, two ounces; gum-gutta, two ounces: red sandal-wood, twenty-four grains; dragon's-blood, sixty grains; oriental saffron, *thirty-six grains*; pulverized glass, four ounces.

Pale Lacquer for Brass.—Alcohol, eight gallons; dragon's-blood, four pounds; annatto, twelve pounds; gum-sandarach, thirteen pounds; turpentine, one gallon.

Lacquer Varnish.—Add sufficient turmeric and annatto to lac-varnish to give the proper color; then strain.

Iron Lacquer.—Three pounds asphaltum: half-pound shellac; one gallon turpentine.

Dipping Acids.

AQUAFORTIS BRONZE DIP.—Nitric acid, eight ounces; muriatic acid, one quart; sal-ammoniac, two ounces; alum, one ounce; salt, two ounces; water, two gallons. Add the salt after boiling the other ingredients, and use hot.

BROWN BRONZE DIP.—Iron scales, one pound; arsenic, one ounce; muriatic acid, one pound. A piece of solid zinc, one ounce in weight, to be kept in while using.

Brown Bronze Paint for Copper Vessels.

Tincture of steel, four ounces; spirits of nitre, four ounces; essence of dendi, four ounces; blue vitriol, one ounce; water, half pint. Mix in a bottle, and apply with a fine brush, the vessel being full of hot water. Varnish over the paint.

Enamels.

WHITE ENAMEL.—Potash, twenty-five parts; arsenic, fourteen parts; glass, thirteen parts; saltpetre, twelve parts; flint, five parts; and litharge, three parts.

BLACK ENAMEL.—Clay, two parts; protoxide of iron, one part.

BLUE ENAMEL.—Fine paste, ten parts; nitre, three parts. Color with cobalt.

GREEN ENAMEL.—Frit, one pound; oxide of copper, half an ounce; red oxide of iron, twelve grains.

YELLOW ENAMEL.—White lead, two parts; alum, white oxide of antimony, and sal-ammoniac, each one part.

Tracing Paper.

Nut-oil, four parts; turpentine, five parts; mix and apply to the *paper,* then rub dry with flour and brush it over with ox-gall.

Inks.

INDIAN INK.—Finest lamp-black made into a thick paste with thin isinglass or gum-water, and moulded into shape. It may be scented with essence of musk.

INDELIBLE INK FOR MARKING LINEN, ETC.—Juice of sloes, one pint; gum, half an ounce. *Another:* Nitrate of silver, one part; water, six parts; gum, one part.

PERPETUAL INK FOR TOMBSTONES, ETC.—Pitch, eleven parts; lamp-black, one part; turpentine, sufficient; mix while warm.

COPYING INK.—Add one ounce of sugar to a pint of ordinary ink.

Composition for rendering Canvas Water-proof.—Yellow soap one pound, boiled in three quarts of water; add while hot to one hundred and twelve pounds of paint.

Water-proofing for Boots.—Linseed-oil, one quart; beeswax, six ounces; spirits of turpentine, four ounces; Burgundy pitch, one ounce. Melt the wax and oil together and dissolve the pitch in the turpentine; pour both into a jar, and place it in a saucepan with water, boil and stir till well mixed. Beware of fire getting near it, as it is very inflammable.

To Water-proof Cloth.—Make, after the following manner, two separate solutions:—1, dissolve one pound of sugar of lead in one gallon of water; 2, dissolve one pound of alum in one gallon of water. Dip the cloth first in the solution of lead, and when nearly dry dip it in the solution of alum, then dry it in the air or before the fire. This process may be used for coats.

To Preserve Sails.—Slaked lime, two bushels. Draw off the lime-water and mix it with one hundred and twenty gallons water; add blue vitriol, quarter pound.

To Preserve Wood-work.—Boiled oil and powdered charcoal, each one part; mix to the consistency of paint. Lay on two coats.

To Clean Brass.—Brass that has not been gilt or lacquered may be cleaned by washing with alum boiled in strong lye, in the proportion of an ounce to a pint; afterwards rub with strong tripoli.

To Prevent Iron from Rusting.—Warm it, then rub with white-wax; warm again to allow the wax to pervade the entire surface.

Or immerse the iron in boiled linseed-oil, and allow it to dry upon the metal.

Stains (*to remove*).—Stains of iodine are removed by rectified spirit. Ink-stains by oxalic acid. Ironmould by the same; but, if obstinate, moisten them with ink, and remove both the old and new stain by the use of muriatic acid diluted by five times its weight of water.

Red spots on cloth can be removed by spirits of ammonia.

To clean gold lace, use cyanide of potassium.

MARKING-INK, OR NITRATE OF SILVER.—Wet the stain with fresh solution of chloride of lime, and, when the mark becomes white, dip the part in solution of ammonia. Wash out with clean water.

To Preserve Objects of Natural History.—White arsenic, one pound; powdered hellebore, two pounds.

To Preserve Gun-barrels.—Corrosive sublimate and lard will protect them from the effects of sea-air.

Watch-maker's Oil.—Place thin sheet lead in a bottle with olive oil, expose to the sun for some weeks, and pour off the clear oil.

To Polish Wood.—Rub with pumice-stone and water, then polish with powdered tripoli and boiled linseed-oil.

Colors for Working Drawings.

Material.	Representative colors.
Brass	Gamboge or chrome yellow.
Brick-work	Carmine.
Cast-iron	Neutral tint or gray.
Clay or earth	Burnt umber.
Concrete	Sepia with dark markings.
Copper	Carmine or lake.
Granite	Pale Indian-ink.
Lead	Indian-ink tinged with Prussian blue.
Steel	Pale blue tinged with lake.
Water	Cobalt.
Woods	Burnt sienna, or raw sienna for light woods.
Wrought iron	Prussian blue.

The usual method is to color at least all the sectional parts; when both parts are colored, the sectional are colored darker than the other parts.

Tempering Steel.

Color.	Temperature.	Purpose.
Light straw	430°–440°	Turning tools for metals.
Dark straw	470°–480°	Tools for wood, screw-taps and dies.
Dark yellow	500°	Hatchets, chipping-chisels, saws, etc.
Light purple	530°	Hatchets, chipping-chisels, saws, etc.
Dark purple	550°	Springs, etc.

Preservative for Steel.

Caoutchouc, one part; turpentine, sixteen parts; and boiled oil, eight parts; well mixed and boiled together. The caoutchouc should first be dissolved in the turpentine by a gentle heat, and the boiled oil added. It should be applied with a brush, and it may be removed by turpentine.

Sizes for Lightning-Conductors.

Copper rod	$\frac{3}{4}$ in. diameter.
Copper pipe	$1\frac{1}{8}$ in. diameter, $\frac{1}{8}$ in. thick.
Iron rod, galvanized	$1\frac{3}{4}$ in. diameter.
Iron pipe	$2\frac{1}{2}$ in. diameter, $\frac{3}{8}$ in. thick.
Flat copper bar	3 in. wide by $\frac{1}{8}$ in. thick.

Marine Glue.—One part India-rubber; twelve parts mineral naphtha or coal-tar. Heat gently, mix, and add twenty parts of powdered shellac. Pour out on a slab to cool. When used, to be heated to about 250° F.

Glue to Resist Moisture.—One pound glue; one pound black resin; quarter-pound red ochre; mixed with the least practicable quantity of water.

Cement for Cloth or Leather.—Eight pounds gutta-percha, cut small; two pounds India-rubber; one pound pitch; half-pound shellac; one pound linseed-oil; melted together and well mixed.

20

Distemper Colors.

WHITE.—Whiting one-third hundredweight; glue six pounds.

YELLOW.—Whiting one-third hundredweight; yellow ochre, two-thirds hundredweight; glue, ten pounds.

The glue is made into size and added hot to the whiting, etc., mixed with water in sufficient quantity to give it the proper consistency for use.

WHITEWASH.—For outside exposure, slaked lime, one-half bushel; add common salt, one pound; sulphate of zinc, one-half pound; and sweet milk, one gallon.

BRILLIANT WHITEWASH.—Lime, one-half bushel; add a strong solution made with a peck of salt; three pounds boiled rice paste; one pound of Spanish whiting; one pound of dissolved glue; and five gallons of hot water, all well mixed and retained four days before use.

Cement for Coating the Inside of Outer Bottoms of Iron Ships.

Roman cement	338	parts.
Pitch, mineral	325	"
Lime, white	82	"
Resin	13	"
Tar, mineral	32	"
Total	790	parts.

The pitch is to be boiled for four hours, the cement, lime, and resin being added in small quantities, and care taken that they are well mixed in, that the resin is well powdered, and the lime free from lumps; after which the tar is added.

Before using, the bottom should be well scraped and cleaned, then payed with a thin coat of hot boiled mineral-tar.

Limes, Cements, Mortars and Concretes.

The calcination of marble or limestone produces lime. The property of hardening under water is effected by the presence of such substances as silica, alumina, iron, etc. Slaked lime is a hydrate of

lime. Roman cement is made from lime of a peculiar character found in England and France. Salt water has a tendency to decompose cements of all kinds.

MORTAR.—One part of lime to three of sharp river sand.

COARSE MORTAR.—One part lime to four of gravelly sand. A small quantity of hair is sometimes added.

CONCRETE OR BETON is a mixture of hydraulic mortar with coarse substances, such as gravel, shells, mashed brick, etc.

Disinfectants.

These substances are of various kinds, and act in different ways. The choice of the agent must depend somewhat upon the circumstances of the case, but for general use, carbolic acid and its preparations, and chloride of lime, appear to be the most efficacious.

CARBOLIC ACID.—In adding this disinfectant to bilge-water or other liquid, it should first be mixed with one hundred parts of water to completely dissolve it, otherwise the acid will merely sink to the bottom, softening any cement with which the bottom of an iron ship may be coated. To purify air, a little of the acid, unmixed with water, should be placed in a saucer. Several patent disinfecting powders are preparations of carbolic acid.

CHLORIDE OF LIME.—This is a very efficient disinfectant, but deteriorates considerably by keeping, unless well preserved from the action of the air.

TO FUMIGATE A SHIP.—Chlorine is perhaps the most powerful agent for this purpose. It may be evolved from chloride of lime by the addition of a little water or dilute sulphuric acid. It may also be obtained by pouring four parts of hydrochloric acid on one part of binoxide of manganese, placed in a shallow vessel and gently heated. The vessel should be placed high up, as the gas falls, and all exits should be closed.

In many cases, the burning of a small piece of sulphur will be found a very efficacious means of disinfecting the air of a cabin or room, which must, however, be made air-tight to retain the sulphurous acid gas.

Clothing may be disinfected after contagious diseases by being

plunged into boiling water. Linen and under-clothing should be immersed in water at 212° F.; uniforms or cloth-clothing, which might be injured by water, should be baked in an oven at a temperature from 212° to 260° F., but as this method is not so convenient, it may be necessary to resort to boiling water.

Clothes dipped in a solution of chloride of lime, one pound to the gallon, may be hung up in an inhabited room to disinfect the air.

SEASONING TIMBER.

Natural Seasoning.

The timber is exposed freely to the air, in a dry place sheltered from the wind and sun, and is so stacked as to admit of the air passing over the surfaces of all the pieces. From two to four years will be required to season it properly.

Seasoning by a Vacuum.

The timber is placed in a chamber from which the air is exhausted, heat being employed to vaporize the exuded juices, the vapor being conveyed away by means of pipes surrounded by cold water.

Seasoning by Hot Air.

(*Davidson.*)

The timber is placed in a chamber, and exposed to a current of hot air, impelled by a fan at the rate of about one hundred feet per second, the air-passages and fan being so arranged that one-third of the volume of air in the chamber is blown through it per minute.

The temperature of the air varies for different kinds of timber, being about 105° for oak, 300° for mahogany, 120° for pine, and from 90° to 100° for leaf-wood in logs.

Water Seasoning.

The timber is immersed in shallow water—salt is better than fresh—and allowed to remain for periods ranging from ten to twenty years. *It is sometimes* allowed to remain but a couple of weeks, when it is

taken out and stood upright in some sheltered place, where it is exposed to the air until quite dry. Again, it is sometimes boiled or steamed for a day or two, instead of being immersed in cold water for longer periods. All of these processes tend to injure the strength of the wood, making it very soft, although acting to prevent cracking, warping, and shrinking.

Slowly seasoned timber is tougher and more elastic than that which is quick dried. Seasoning by heat alone is very injurious to timber. For joiners' and carpenters' work, natural seasoning has the preference.

PRESERVING TIMBER.

Creosoting.

(Bethell.)

The timber is first well dried by one of the processes, and is then placed in a strong iron cylinder and subjected for thirty or forty minutes to a vacuum of six to twelve pounds per square inch. The creosote is then allowed to flow in, and a pressure put upon it, varying from one hundred to two hundred pounds per square inch, for from one to three hours.

Another process consists in simply immersing the timber in an open tank containing hot creosote, the temperature being kept up to about 130° to 160° F., and left for some time to the natural process of absorption.

Ordinary fir-timber absorbs from eight to ten pounds of creosote per cubic foot; red pine, from fifteen to sixteen pounds; oak, from four to five pounds. This method of preserving timber is much used, and is a sure preventive against the attack of the teredo and other marine worms.

IMPREGNATION WITH METALLIC SALTS.

Kyan's Process.

This consists in immersing the timber in a solution of bichloride of mercury diluted with from one hundred to one hundred and fifty parts of water, or one pound to two-thirds of a pound of the salt to ten gallons of water. Twenty-four hours are generally allowed for each inch in thickness for boards.

Margary's Process.

Margary employed sulphate of copper diluted with forty to fifty parts of water, applied with pressure of fifteen to thirty pounds per square inch for six or eight hours.

Burnett's Process.

A solution of one pound of chloride of zinc to five gallons of water is injected, and applied with a pressure of one hundred to one hundred and twenty pounds per square inch for fifteen minutes. The timber is then taken out, and allowed to dry for about two weeks.

Payne's Process.

This consists in impregnating the timber with a strong solution of sulphate of iron, and afterward forcing in any of the carbonate alkalies.

INTERNAL ECONOMY.

Scraping Spars.—Send light booms on deck, and scrub them with sand and canvas.

In the case of top-gallant masts, merely scrape the dirt off, and then give them a light plane over at long intervals, which is less injurious to them than constant scraping with knives.

Cleaning and Whitening Decks.—Holy-stoning too frequently makes the deck rough. A sprinkle and scrub with hand-brushes or hand-swabs is preferable, as the decks dry rapidly, and heavy holy-stoning is rendered less necessary.

For lower-decks, hot water and American potash applied over night, and washed off the next morning with hot water, will cleanse and whiten the decks wonderfully.

Replacing Copper under Water.—Construct a water-tight case of three sides and a bottom; cut the mouth or open side of the case to fit the curve of the ship; line the curved edges with felt, saturated with tallow, and attach ballast to the bottom.

Suspend the case by a tackle from the rail, and lower it over the defective part, using a line to haul it down passed under the keel *from the opposite* side, and a second line for a horizontal guy.

Set both lines taut with tackles, and cause the case to fit closely, after which secure it with a shore to prevent rising.

Exhaust the water from the case by a suction-hose and pump, and, when empty, send a man inside to replace the copper.

This method, which will answer for five or six feet below the water-line, may also be used to repair cocks and pipes.

Dressing Ship.

From flying-boom end to fore top-gallant mast-head	Pendant and square flags alternately.
Thence to main top-gallant mast-head	Same arrangement.
Thence to mizzen top-gallant mast-head.	Same.
Thence to peak. Thence to boom end.	Square flags.

From spanker-boom end hang ships' pendants, and from the flying-boom end the number, a lead being attached to each to keep them from flying away.

Top-gallant yards are not usually sent down the evening before dressing ship.

The flying-jib and royal halyards are used to trice up by, rove through blocks at the mast-heads with down-hauls attached; and the flags, in addition to being stopped at the head and tack, are stitched to the halyards amidships.

Reeve them beforehand and bend on the flags, and at two minutes before eight trice up mast-head ensigns made up, and send aloft the captain of each top and two hands, one of whom going to the mast-head stops the tack in when broke, or holding the flag broken, but rolled up, throws it clear at the word; the other hand remaining in the top, clears the flags should they foul.

When dressing in honor of a foreign power, courtesy requires the colors of that power to be displayed at the main top-gallant mast-head.

On a shift of wind, or at the turn of the tide if lying in a tideway, send hands aloft *together to* clear the flags.

Anchoring in a Foreign Port.

After the salute to the flag, the admiral of the port is saluted, and, if necessary, the governor also. In the salute to the admiral the jib is run up at the first gun and hauled down at the last gun. This indicates a salute to some one afloat.

Stowing Provisions.

Before commencing to stow, the holds should be well cleaned and whitewashed.

WET PROVISIONS are salt beef, pork, vinegar, etc.

DRY PROVISIONS are flour, sugar, coffee, raisins, peas, beans, oatmeal, etc.

Provisions should be stowed in the holds so that each kind may be got at. Old provisions should always be cleared out of the hold before stowing the new, then stowed on top to be used first.

Wet provisions should form the ground tiers, the dry provisions the top tiers. Beef and flour may be stowed on the starboard side, pork, etc., on the port side.

Casks should be placed fore and aft, bung up, and dunnage placed under the chimes to prevent shifting. In the spirit-room casks are stowed bung up and bilge free.

Biscuit is stowed in the bread-room.

Each cask has the contents and date of package marked on it.

Tanks are stowed with their tops level, and with the corners in which the man-holes are adjoining. They should be wedged up taut and caulked in.

To Calculate the Capacity of a Cask.—Multiply half the sum of the area of the two interior circles—viz., at the head and bung—by the interior length in cubic inches, which, divided by 277.27, the number of cubic inches in a gallon, reduces the result to that measure.

Example.—A cask measures 21 inches in diameter at the bung; 16 inches at the head; and 28 inches in length: then 346.4 and 201.1 would be the respective areas, and their half sum, 547.5, multiplied 28 and divided by 277.27, gives 27.65 gallons for the contents, *at the capacity* of a beef barrel.

Up-ending a Large Cask.—Lay a capstan-bar under the bilge on each side; span them together under the chimes of the cask at each end; man the bars and up with it, sticking to it on the opposite side to prevent it going over.

To Ascertain the Quantity of Water a Boat will Bring off.—A butt holds 110 gallons, a puncheon, 72 gallons. Water may be computed at 210 gallons to a ton. The boat stows from 2,000 to 3,000 gallons, or between ten and twelve tons.

Bringing off Water in Bulk.—See the boat clear, wash her out with fresh water; keep the bottom boards and a few oars or thwarts loose in her to prevent the water surging about when she is loaded.

Rafting Water off.—Knock the outer hoops off each end of the casks, and drive them on again with a becket underneath, for a hauling-line to pass through between the beach and the boats anchored outside the surf.

Units of Measurement.—The size of spars, dead-eyes, and chains is expressed by their diameters; of rope, by its circumference; blocks, by their length; hand-masts, by their circumference in hands four feet from the heel.

Hoisting in Cattle.—Cattle should be hoisted in by the horns, only when the animals are very small and their horns very strong. The preferable method to pursue in all cases is as follows: hook on the yard and stay to a strap round the beast's neck, putting his fore-leg through it to prevent his being choked.

Hoisting in Horses.—Cover the eyes, hobble and sling with a broad mat or canvas-slings under the belly, with a crupper from the haunches round the chest to keep the slings from shifting. Lead the halter through a ring-bolt on deck, and take through the slack as the horse comes in. A strap round the nose, hove short with a toggle, will rapidly tame an unmanageable horse. Horses should be kept slung in their stalls at sea, with their hoofs just resting on the deck.

Extemporary Measurements.

It is at all times well to know the length of the different joints of the limbs.

Suppose the nail-joint of the forefinger to be one inch, the next joint will be 1¼ inch, the next 2 inches, and from the knuckle to the wrist, 4 inches; in this case the finger is bent, so that each joint may be measured separately, though, when held straight, the distance from the tip of the forefinger to the wrist would be only 7 inches. The span with thumb and forefinger would be 8 inches, and with the thumb and any of the other three, 9 inches, or equal to the length of the foot; from the wrist to the elbow would be 10 inches, and from elbow to forefinger, 17 inches, and from collar-bone to forefinger, 2 feet 8 inches; height to the middle of knee-cap, 18 inches. From the elbow to the forefinger is usually called a cubit, but it is seldom strictly so, an English cubit being generally stated as 18 inches.

In like manner, the full stretch of the extended arms is called a fathom, but it is generally somewhat less. If a man stands with his back to a flat wall, and extends his arms, his fathom will be scarcely equal to his own height; but if he tries to measure the girth of a tree, by placing his breast against, and, as it were, embracing it, he will find his fathom many inches short, and, on an average, perhaps not more than five feet.

The pulse when in health, and not excited, beats 72 to 75 times in a minute.

The pace is commonly supposed to be 2½ feet, but this is a most uncertain mode of measurement. Very few men, without practice, can take correctly a hundred consecutive steps or paces of the same length. Practice will determine the amount of ground covered in a certain number of paces, if tried over known distances; it, of course, varies, but from experiment, the mean has been found nearly as follows:

Pacing, at 30 inches per pace, of 108 in a minute, equals 270 feet, or 3.068 statute or 2.66 nautical miles per hour.

Pacing quickly, at 30 inches per pace, or 120 in a minute, equals 300 feet, or 3.41 statute or 2.96 nautical miles per hour.

Pacing slowly, at 36 inches, may average 60 per minute, equals 180 feet, or 2.04 statute or 1.78 nautical miles per hour.

Section 6.

BOATS, CLASSIFICATION OF, ETC.

STEAM-LAUNCHES.

MANAGEMENT OF STEAMERS.

DIMENSIONS OF BOATS, FITTINGS, RIGS, ETC.

LOWERING AND HOISTING.

PRACTICAL HINTS ON MANAGEMENT.

BOARDING WRECKS, RIDING OUT GALES, BOAT CRUISING, CROSSING BARS, ETC.

MANAGEMENT OF BOATS IN A SURF BEACHING, ETC.

BOAT-WORK. RUNNING WARPS, CREEPING FOR ANCHORS, CARRYING OUT ANCHORS, ETC.

ENGLISH BOAT RACING RULES.

SOUNDING AND NAUTICAL SURVEYING.

VESSELS GETTING ON SHORE, LEAKS, ETC.

INSTRUCTIONS FOR DIVERS.

BOATS.

SHIPS' BOATS are either *clinker*, *carvel* or *diagonal-built*. *Carvel* and *clinker* boats are timbered; in the former, the planking is smooth (*flush*), in the latter, the lower edges of the upper strakes overlap the lower strakes. *Diagonal-built* boats are not timbered, but the planking is double, rising in opposite directions from the keel at an angle of 45°.

All boats are fitted with chain-slings for hoisting, and it is recommended to place these slings away from the extreme ends of the boat, to avoid straining when up at the davits. The hooks should be on the slings and the rings on the lower blocks of the boat-falls to avoid tearing out thwarts in a sea way.

Plug-holes may be closed with a leather-hinged door, opening downward; or by a plug in the usual way, in which case the plug should be fastened near at hand by a lanyard.

Many large boats are fitted with pipes and a windlass, to raise or carry a heavy weight underneath.

Boats are square-sterned or sharp at both ends. *Single-banked* boats have one oarsman to each thwart, and *double-banked* boats have two. Oars are double-banked when each oar is pulled by two men.

To *feather* the oars, is the art of turning the blades to a horizontal position, that they may not hold the wind, and boats' crews should always be required to feather their oars when rowing.

TO FIND THE WEIGHT OF SHIPS' BOATS.—Multiply the square of the breadth by the length, and that product for a launch by 2.5; first cutter by 1.9; second cutter by 1.4; smaller boats by 1.0. Answer will be in pounds.

Classification of Boats.

In the Navy, the usual classification of boats is as follows, viz.:

Steam-launches and steam-cutters.

Sailing-launches, cutters, whale-boats, gigs and dingies.

STEAM-LAUNCHES.

The ordinary type of navy steam-launch carries 960 pounds of coal in the bunkers, and 2,500 pounds of water in the tanks. This boat can maintain a speed of seven miles an hour for about four consecutive hours, after which the tanks must be refilled. The maximum speed is about eight miles per hour. The usual pressure of steam is from 40 to 60 lbs. per square inch, but 80 lbs. may be used if necessary. The steam is not condensed, but is usually exhausted into the funnel to cause an increased draught.

The *Herreschoff* navy-launch is about thirty-three feet in length, and has eight feet six inches beam.

The engines are compound, having two cylinders, connected at right angles, thus giving complete control of the boat as to starting, stopping, and backing. The pressure is from forty to sixty pounds per square inch above the atmosphere, but the engines are capable of running under a pressure of one hundred and fifty pounds, if necessary.

It has an extremely light coil-boiler, and the weight of water contained therein is reduced to a minimum.

The steam is exausted into a surface-condenser, formed by a copper-pipe secured to the outside of the hull just above the keel. The boiler is thus kept supplied with fresh water, and the quantity lost by leakage is restored from a small tank beneath the boiler. The launch carries 1,120 pounds of coal, and can maintain a speed of seven miles for twenty-eight consecutive hours.

The maximum speed is eleven miles per hour.

The weight of this boat is one-half, and its economy of fuel double that of the ordinary type of navy-launch. It has greater carrying capacity, is noiseless when under way, and is a fine sea boat.

Remarks on Steam-Launches.

A steam-launch should be strong enough to hold its engines and boilers with steam up, coal, etc., before it is lowered; should be fitted to use salt water and to work in a rough sea.

All steamers should be decked over, and should have sufficient *buoyancy to float* engines, coal, and crew, in the event of being

filled by a sea. When a condenser is used, it is possible to greatly increase the boiler power without increasing the weight above that gained by doing away with the water in tanks usually carried.

The best steam-launches are now built of steel, and fitted with air-tanks.

Instructions for Working the Engines of Steam-Launches, etc.

The following instructions for working the engines of steam-launches are introduced; as it is possible that the officer in charge might be thrown entirely on his own resources.

THE engine should not be removed from the boat oftener than can be helped. The boiler of steam-pinnaces should be lifted, examined at the bottom, and painted every month.

See that the tanks, fitted for the purpose, are properly supplied with coal and fresh water.

The connection with propellers and water-tight joints must be made good before leaving the ship.

Water is run into the boiler through a hose by removing one of the safety-valves.

When the water is showing from one-half to three-fourths up the gauge-glass, remove the hose and replace the safety-valve. Great care must be taken to see that the valve and its seating is perfectly clean before the valve is replaced.

To Get Up Steam.—Put a surface of coal over the fire-bars, shut the ash-pit door, and light up with wood and coal at the front until a sufficient body of fire is obtained to ignite the coal on the bars, when the fire may be pushed back, and the ash-pit door opened.

When the steam begins to show by the gauge, try the safety-valves, and use the blast (if the steam be required in great haste) until sufficient pressure be obtained.

Try the small engine to supply feed-water, and make sure of the water supply independent of main feeds.

THE BOILER will require the most careful and constant attention while steaming. When attainable, fresh water should always be used.

It is fitted with every requisite for efficiency and safety.

From forty to fifty pounds of steam pressure is quite sufficient for all ordinary service. Leaks about tubes and tube-plates are most frequently caused by forced steaming.

The water must never be allowed to go below the mark of low level.

At high speed it is liable to show higher in the gauge-glass than it really is.

The gauge-glass and gauge-cocks must be frequently tried, the one being a check on the other. The water moving in the glass with the movements of the boat is another proof of gauge-glass cocks being correct.

Care should be taken to prevent spray from striking the gauge-glass, as it is very liable to break it.

Maintain a sufficient quantity of water in the boiler, and keep the feed-water supply as nearly constant as possible. In the event of the water getting low, the fire must be checked as quickly as possible; to effect this, open the smoke-box door, shut the ash-pit door, and throw on wet ashes. In an extreme case, draw the fire.

In the new class of boats, the feed-water passes through a coiled-pipe in a cistern secured to the boiler. This cistern receives the exhaust steam from the engine, heating the feed-water on its passage to the funnel; doing its work in a noiseless manner, instead of the intermittent puffing which is the result of direct connection.

Starting the Engine.—Have every frictional part of the engine carefully oiled, especially cylinders, slide-valves, eccentrics, cranks, and thrust open the small drain-cocks in connection with the cylinders and slide-valves to get rid of condensed water, and let them remain open for a few turns of the engines. The steam-cock may *be left a little* open while steam is getting up, to warm the engine.

Starting ahead or astern is effected by link-motion, and requires no consideration after observing the movement of the handle connected with the link.

Great care should be taken to admit the steam to the engine gently at first, and get up full speed gradually.

Running.—Attention to the engine is required in preventing the overheating of working parts.

Any *unusual noise* must be quickly attended to, and cause ascertained; the loosening of pin, key, or screw promptly remedied, always bearing in mind the old adage about "a stitch in time," etc.

Sea-Water.—If obliged to use sea-water for the feed, let the process of brining be as constant and continuous as possible.

The density of the water in the boiler must be frequently tested by drawing some off and applying the hydrometer, with the water at the temperature of its graduated scale.

The brining, or blowing-out, should maintain the water at $1\frac{3}{4}$ charges of salt (salt water being 1), or about the mark 18 on the hydrometer in general use.

Stoking.—The stoking must be careful and frequent, in just sufficient quantity to keep the fire-bars properly covered. Attention to this will go far to prevent priming. Keep the steam at a regular pressure, and the fire-bars free from clinkers, by hooking them out as soon as formed.

The tubes, fire-box, smoke-box, and the space at the back of the fire-bridge, should be kept free and clean. This must be done as opportunity offers.

If the screw of a steam-launch is taken off for the purpose of her being used as a sailing-boat, the brass bush, usually provided for the purpose, should be put on the end of the shaft (first coating it with white-lead and tallow) in order to protect it from the rapid galvanic action which takes place by its close proximity to the copper-sheathing on the boat's bottom. If no bush is provided, then the end of the shaft should be lapped round with spun-yarn well saturated with stiff white-lead and tallow.

BOATS AND BOAT-WORK.

Memorandum of Dimensions for Boats, U. S. Navy.

Launches.......	Breadth = length	× .282.	Depth = breadth	× .40.
Steam-cutters...	" = "	× .260.	" = "	× .46.
Cutters	" = "	× .258.	" = "	× .37.
Barges	" = "	× .225.	" = "	× .37.
Gigs	" = "	× .185.	" = "	× .37.
Whale-boats	" = "	× .210.	" = "	× .39.
Dingies	" = "	× .265.	" = "	× .37.

Length of	Wabash and class.	Guerriere, Lancaster, and class.	Severn, Pensacola, and class.	Ticonderoga, Plymouth, and class.	Iroquois and class.	Shawmut and class.
	FT.	FT.	FT.	FT.	FT.	FT.
Launches	34	34	32	32	30	28
Steam-cutters	33	33	33	33	—	—
First cutters	30	30	28	28	26	26
Second cutters	28	28	28	26	26	24
Third cutters	28	28	26	26	26	24
Fourth cutters	26	26	26	—	—	—
Whale-boats	29	29	29	27	27	27
Barges	32	32	30	—	—	—
Gigs	30	30	28	28	28	—
Dingies	20	20	18	18	18	18

Boat Equipments.

It is a good plan to fit a permanent boat-chest in every boat.

All masts should step in a box and clamp to the thwart.

The various classes of boats should be of a uniform rig. Sailing-launches are generally sloop-rigged, having one mast upon which are set a jib and main-sail. A rig which has many advocates, however, is two lug-sails, the forward one being the larger, and cut to the yard so that the forward part of the sail acts as a jib.

For cutters and whale-boats the *sliding gunter-rig* has been *adopted, though* advocates of the lug-sails are not wanting.

Department.	Articles.		Steam-launches or steam-cutters.	Sailing-launches and 1st cutters.	All other cutters.	Gigs and whale-boats.
BOATSWAIN'S.	Anchor	each	1	1	1	1
	Anchor-chain or rope	"	1	1	1	1
	Hand-grapnel	"	1	1	1	1
	Hand-grapnel line	"	1	1	1	1
	Painter	"	1	1	1	1
	Marline-spike	"	1	1	1	1
	Spun-yarn	ball	1	1	1	1
	Grease	pound	1	1	1	1
	Thrum-mats for oars	set	—	1	1	1
	Trailing-lines	"	—	1	1	1
	Fishing-lines	each	3	3	3	2
	Fishing-hooks	dozen	1	1	1	1
	Lanyards for thole-pins	set	1	1	—	—
CARPENTER'S.	Boat-stove in packing box	each	1	1	—	—
	Boat-stove cooking utensils	set	1	—	—	—
	Tinder-box, with flint and steel	each	1	1	1	1
	Fenders, with lanyards	set	—	1	1	1
	Fenders, pudding		1	—	—	—
	Fuel		—	—	—	—
	Boat-box (see foot-note)		1	1	1	1
SAILMAKER'S.	Sails	set	—	1	1	1
	Sail-covers	"	—	1	1	1
	Boat-cover	each	1	1	1	1
	Spar-cover	"	—	1	1	1
	Tent-awning	"	1	1	—	—
	Awning	"	—	1	1	1
	Awning-bag	"	1	1	1	1
	Cushions	set	1	1	1	1
	Cushion-covers	"	1	1	1	1
	Cushion-bag	each	1	1	1	1
	Tarpaulin	"	1	1	1	1
	Water-tank	"	—	1	—	—

NOTE.—Boat-box to contain 1 axe, 1 hatchet, 1 hammer, 1 hand-saw, and for launches, 100 tacks, 3 square feet sheet-lead ; for first cutters, 1½ pound nails, 75 tacks ; for all other boats, 1 pound nails, 50 tacks, and 2 square feet sheet-lead.

A sliding gunter-mast consists of two sections, nearly equal in length, called the lower-mast and top-mast. The latter slides upon the former, and is held in position by means of two iron rings secured to the top-mast near its lower end.

The sail is bent to the top-mast and *laced* to the lower-mast, in order to allow the top-mast to lower freely. The spread of sail may be quickly reduced by lowering the top-mast.

Cutters have two of these sails and a jib, but whale-boats have the two sails and no jib.

Small cutters are sometimes rigged with two *sprit-sails* and a jib. The upper end of the *sprit* is placed in a grommet at the peak of the sail, while the lower end rests in another grommet on the lower part of the mast.

Whale-boats are sometimes fitted with two sprit-sails. Gigs are furnished with one sprit-sail and a jib extending to the stern of the boat.

Dingies have one sprit-sail, and the mast must step far enough from the bow to allow the sail to be used on a wind.

Lowering and Hoisting.—In lowering, have a line from forward, outside all; rudder shipped, plug in, and quarter-ladders over. The boat-keepers hold on by life-lines until the boat is in the water. Unhook the after tackle first.

In hoisting, the boat should be hauled up by a line from forward a careful hand steering, and the forward tackle hooked first. When the tackles are hooked, the keepers should haul the blocks taut up by the standing part of the fall. In a seaway, cross the life-lines and keep them taut through the bow and stern rings, and as the boat rises bind her by steadying-lines. One or more light spars may be put down from the mizzen-chains and used to bear the boat clear as she swings in.

In a stern boat in a tideway, do not hook the stern tackle until all is ready on deck, then hold hard by the life-lines as she flies forward. A guy may be used to steady her from the boom-end, and in case of heavy rolling, the life-lines should be crossed.

At least one boat should be a surf or life-boat, and fitted for lowering and hoisting with great expedition.

Boats should have their recall and the general recall painted on tin, and tacked inside the stern sheets.

Practical Hints for the Guidance of Officers and Others having Charge of Boats.

Before leaving the ship see that the boat's gear, such as masts, sails, oars, fenders, boat-hooks, baler, anchor and cable, painter, flags, breakers, water, rudder, awning and stanchions, is complete, and that she is properly equipped for the service on which she may be going. Compass and lead-line may be required. Spy-glass, watch and sextant, note-book and signal-book should be the especial care of the officer in charge. If the boat is to be away for any length of time, spare clothes, provisions and gear should also be carefully mustered, and it is well to make sure that *orders* are rightly understood before leaving the ship.

At night, or in thick weather at sea, or when far from the land, do not leave the ship without a compass, remembering before starting to get a bearing of the place or ship it is required to reach. Take a bearing of your own ship on losing sight of her by night or in a fog.

Do not shove off during sternway, else the ship in setting to leeward and falling off may bury the boat under her bows, or with her stern and dolphin-striker cut the boat down.

If about to sail, get the sails taut up before shoving off in case the ship is head to wind, but if not head to wind, pull well clear of her before making sail. See that the sails are properly set. In boats where the jib acts as the fore-stay, set the jib before the fore-sail; or, if obliged to set it afterward, ease off the fore-sheet to allow the mast-head to go forward into place.

As a rule, in sailing, make the crew sit well down in the boat—on the bottom boards if necessary.

The rule of the road for boats is the same as for ships.

Keep weights amidships, and *never belay the sheets.*

To Dip a Lug.—Tell off the men: the bowmen to bear the fore part of the sail out; the two next to gather the sheet forward, and pass it round; the after-hands to unhook and hook the sheet, if fitted single; the others to shift the halyards, hand the foot along, and hoist when ready. Do not lower until the fore part of the sail has been aback long enough to bring the wind on the other bow. Have the *halyards marked,* so as not to lower more than is necessary

to dip the after yard-arm. Tend the main-sheet while hoisting the fore-sail.

As a general rule, a reef should be taken in directly the boat begins to wet.

Before reefing on a wind, tell the men off for the different duties: the two bowmen to gather down on the luff; the weather-hands by the halyards and down-hauls; the lee-hands to tie the reef points; one stroke-oarsman to attend the sheet, the other to assist the coxswain in reefing the mizzen. No person need stand up.

Do not luff up. Check the sheet; lower enough to shift the tack easily. Gather aft the sheet, that the men may reach the foot of the sail without leaning over the gunwale. Shift the sheet; tie away. Slack the sheet; hoist. Resume places and haul aft. Allow the boat to get steerage-way before hauling aft the main-sheet. When you want a pull of the halyards, ease the sheet. Remember, when running, that you cannot carry all the canvas on a wind that you can before it; therefore make ready for rounding-to.

Running dead before the wind in a gig is very dangerous. Little time is lost, and it is much safer to run half the distance with the wind well on one quarter; then lower, dip the sail, and bring the wind on the other quarter.

If the men are sitting to windward in a breeze, make them occupy their proper places amidships before passing to leeward of a vessel.

Trimming a boat requires great attention; if properly done she should almost steer herself. A tendency to carry lee helm should be counteracted at once.

Do not put the helm down too suddenly, or too far over; 42° is the extreme of efficiency. In sternway, when the rudder is hard over, great strain is brought on the braces and pintles. If there is any doubt about weathering a ship, or danger, "go about" in time, and avoid drifting, crab-like, on top of the danger. Have an oar ready to assist the boat round in case of necessity. For ballast, use water in breakers.

Squalls.—*If caught* in a hard sudden squall; down helm at once, let fly the fore-sheet, and lower the sails. In a moderate squall ease the sheets; keeping such steerage way as to ensure a touch of the helm and pull of main-sheet bringing her into the wind.

Keep the boat stem on to a heavy sea.

Going Alongside.—In going alongside, lay the fenders out and get the bowsprit unshipped in good time.

If the boat is under sail and the ship to windward, make a tack to windward of the ship, unstep the masts and pull alongside; but, if coming up in any direction abaft the beam, unstep the fore-mast, when you are sure the after-sails will carry the boat alongside, and down with the main-mast when you have the boat rope.

Before going alongside a vessel under way and hove to, observe if she have head or sternway, and in any case get the mast down before closing her. Wait until the ship has gathered way, and then go alongside.

In a strong breeze, always get the masts down before coming alongside. Either round-to ahead, down masts, out oars, and drop down; or, shoot up under the stern, and down masts before getting under the boats.

Make due allowance for the rate at which the tide is going past the ship, or the speed of the ship. A current frequently sets close along shore in the opposite direction to the one that is setting past the ship, and therefore a little judgment may save a long pull.

Boarding a Wreck or Vessel in a Heavy Sea.—The circumstances under which life-boats and other boats have to board vessels, whether stranded or at anchor, or under way, are so various that it would be impossible to draw up any general rule for guidance. Nearly everything must depend on the skill, judgment, and presence of mind of the coxswain or officer in charge of the boat, who will often have those qualities taxed to the utmost, as undoubtedly the operation of boarding a vessel in a heavy sea or surf is frequently one of extreme danger.

It will be scarcely necessary to state that, whenever practicable, a vessel, whether stranded or afloat, should be boarded to leeward, as the principal danger to be guarded against must be the violent collision of the boat against the vessel; or her swamping or upsetting by the rebound of the sea; or by its irregular direction on coming in contact with the vessel's side; and the greater violence of the sea on the windward side is much more likely to cause such accidents. The danger must, of course, also be still further increased when the vessel is aground and the sea breaking over her. The chief danger to be apprehended on boarding a stranded vessel on the lee side, it

broadside to the sea, is the falling of the masts; or, if they have been previously carried away, the damage or destruction of the boat amongst the floating spars and gear alongside. It may, therefore, under such circumstances, be often necessary to take a wrecked crew into a life-boat from the bow or stern; otherwise, a rowing-boat, proceeding from a lee shore to a wreck, by keeping under the vessel's lee, may use her as a breakwater, and thus get off in comparatively smooth water. This is accordingly the usual practice in the rowing life-boats. The larger sailing life-boats, which go off to wrecks on outlying shoals, are, however, usually anchored to windward of stranded vessels, and then veered down to one hundred or one hundred and fifty fathoms of cable, until near enough to throw a line on board.

In every case of boarding a vessel at sea, it is important that the line by which a boat is made fast to a vessel should be of sufficient length to allow of her rising and falling freely with the sea; and every rope should be kept in hand, ready to cut or slip it in a moment if necessary. A sharp knife should also be at hand.

In being towed by a vessel, if alongside, contrive to have the line from as far forward as possible; never make it fast, but take a turn and hold the end all clear for slipping, or toggle it with a stretcher through a ring-bolt. If being towed astern, the closer the better.

When boarding foreign men-of-war, the boarding book should not be taken on board, but the information gathered should be entered afterwards. When boarding a vessel in one of our own ports, assistance should be offered if required.

Boarding Merchant Vessels.—Fill up the columns of the boarding-book.

A Gale of Wind in an Open Boat.—Lash your masts, bottom boards, and all oars but two, together; hang boat's anchor to them; span them with the boat's painter, and pitch them overboard.

This will keep you head to the sea, form a breakwater, and prevent your drifting fast. If long enough, pass the end of the painter or line from the spars round the boat outside, guy it down here and there by the bight of a rope passed over the bows and slipped under the bottom; lay the sails over the fore part of the boat, and lace *them down outside* to the painter; raise the after-part by sticking a

stretcher under it, and so keep the seas from breaking into the boat and have a shelter from the weather. Keep the boat baled out, and the breaker rigged to serve as a life-buoy.

Boat Cruising.—Ordinary ship's boats always require to be raised up, to enable them to carry the necessary weight of provisions, water, etc., in addition to their crew, for ten days or a fortnight's cruise. Launches and cutters should have from eight to ten inches added to their gunwale forward, decreasing to about half that height at the stern of the boat. They should have a large locker built in the bows, at least as high as the thwarts, made water-tight, and the top covered with copper or lead, for the purpose of stowing the spare clothing. A similar locker to be built in the after-part of the stern-sheets for the officers. A jack-stay should be fitted round the boat, underneath the rubbing-strake, for lacing down the rain-awning. All boats should be supplied with rain-awnings; two spare oars in addition to the complement; a boat-hook having a stout lanyard secured to the hook and seized two-thirds down the staff, an eye is turned in at the end to which a line should be attached—a boat-hook thus fitted will be found useful when boarding a vessel under way; a small grappling-iron, with a couple of fathoms of light chain; sails, boilers, etc., complete. Short oars should be taken, as the boats when provisioned will be deep in the water. A pump should be fitted under the coxswain's seat to discharge water at the stern.

Boats rigged with two sliding-gunters are the best suited for cruising purposes, being easily handled and made safe in bad weather.

Provisioning and Cooking.—All boats should be fitted with scuttle-butts of such dimensions as to stow conveniently under the boat's thwarts on each side of the keelson. They will be found very useful for carrying both provisions and water, and stow better than breakers, though no boat should be without a certain proportion of the latter for convenience in watering. Bread and meat being the two most bulky articles of provisions, should be reduced as much as possible, and it will often be convenient to supply only half allowance of these articles to boats when detached, furnishing the officer in charge with money to purchase fresh meat, vegetables, etc. On the other hand, in consideration of the duty on which they are employed, double allowance of small stores and spirits may be issued.

The ordinary boat-stove may be placed on the large copper-covered locker in the bows. A small tub of sand with three bricks may be used in smaller boats for cooking purposes.

Clothing and Sleeping.—Each man should be provided with a blanket-frock for sleeping in. He should also have two complete changes of woollen clothing.

The rain-awning should always be spread at night, and the oars so arranged on the thwarts as to form a platform for the men to sleep on. As the health of the men depends in a measure on cleanliness, every opportunity should be taken of clearing, and thoroughly cleansing the boat.

Anchors and Cables.—All boats larger than cutters should be furnished with two anchors; and a short length of chain cable should be added when practicable, as the rope is easily cut through.

Every boat should have a boat-box, or bag, containing all the small gear likely to be required for repairing sails, rigging, etc. Also some fishing-lines and hooks; tools and material for repairing the boat if stove; compass and sextant; lead and line; axe, etc.

No Water.—Twice a day dip your clothes overboard, and put them on wet.

Crossing Bars.—For the purpose of steering a boat in crossing the bar of a river, a steering-oar should be used. A boat should be fitted with a crutch-hole on each quarter whenever practicable, where an oar may be worked to assist or replace the rudder. Some sailors like to pull over bars, others prefer, when the wind is free, to sail. The objection to pulling is, that at the critical moment, when the boat is in broken water, some of the men may catch crabs with oars and cause the boat to broach-to. The best plan when pulling is to toss the oars as the waves break around the boat, giving way as quickly as possible afterwards; but this requires a very well-trained crew.

Under sail, with a good commanding breeze, everything depends on careful steerage. The sail may get slightly becalmed between the rollers, but the face of the advancing roller always raises the boat in time to gather the way necessary for her to be properly handled. In crossing bars, men should be directed to relieve themselves *of all superfluous* garments; the lanyards should be taken off the

oars; and the masts and other buoyant articles left free to float in case of the boat being swamped, a contingency which, to those even who have seen much of such work, is always possible, however well-handled the boat may be.

Landing in a Surf.—Viewed from seaward, a surf has never so formidable an appearance as when seen from the land; persons in a boat outside the broken water are therefore apt to be deceived by it. They should accordingly, if practicable, proceed along the land outside the surf, until abreast of a coast-guard or life-boat station, or fishing village, whence they might be seen by those on shore, who would then signalize to them where they might attempt to land with safety, or else warn them to keep off; or who might proceed in a life-boat or fishing-boat to their aid; the generality of coast fishing-boats being far better able to cope with a surf than a ship's boat, and the coast-boatmen being more skilful in managing boats in a surf than the crews of ships. If in the night, double precaution is necessary—and it will in general be much safer to anchor a boat outside the surf until daylight than attempt to land through it in the dark.

Where a surf breaks at only a short distance from the beach, a boat may be anchored outside the surf, and veered or backed in from her own anchor. In such a case, care should be taken that the cable is of sufficient length to permit of the boat's reaching the beach from a safe position outside the line of breakers. The cable should be bent and everything be in readiness for landing before approaching the shore; on reaching the edge of the breakers, the bow and after oars should be laid in, the bowman attending to the anchor and cable, the coxswain standing by with a small line for a stern fast. On the anchor being let go, the rudder should be unshipped and the boat backed in steadily, but fearlessly, care being taken by the bowman to keep her bow to the sea by not letting her take the cable too fast. On reaching the shore the coxswain should either jump overboard with the stern-fast, or throw it to any persons who may be on the beach. This stern-fast steadies the boat, keeps her bow to the sea, and facilitates the landing. On the landing being effected, the boat can be hauled out to her anchor, taking care if she is wanted to return to the shore to let one end of the stern-fast remain *on the beach.*

MANAGEMENT OF BOATS IN A SURF, BEACHING THEM, ETC.

In Rowing to Seaward.

As a general rule, speed must be given to a boat rowing against a heavy surf. Indeed, under some circumstances her safety will depend on the utmost possible speed being attained on meeting a sea. For, if the sea be really heavy, and the wind blowing a hard onshore gale, it can only be by the utmost exertions of the crew that any headway can be made. The great danger then is, that an approaching heavy sea may carry the boat away on its front, and turn it broadside on, or up-end it, either effect being immediately fatal. A boat's only chance in such a case, is to obtain such way as shall enable her to pass end on through the crest of the sea, and leave it as soon as possible behind her. Of course, if there be a rather heavy surf, but no wind, or the wind off shore and opposed to the surf, as is often the case, a boat might be propelled so rapidly through it, that her bow would fall more suddenly and heavily after topping the sea, than if her way had been checked; and it may therefore only be when the sea is of such magnitude, and the boat of such character, that there may be a chance of the former carrying her back before it, that full speed should be given her.

It may also happen that by careful management under such circumstances, a boat may be able to avoid the sea, so that each wave may break ahead of her, which may be the only chance of safety in a small boat; but if the shore be flat, and the broken water extend to a great distance from it, this will often be impossible.

The following general rules for rowing to seaward may therefore be relied on:

1. If sufficient command can be kept over a boat by the skill of those on board her, avoid or "dodge" the sea if possible, so as not to meet it at the moment of its breaking or curling over.

2. Against a head gale and heavy surf, get all possible speed on a boat on the approach of every sea which cannot be avoided.

If more speed can be given to a boat than is sufficient to prevent *her from* being carried back by a surf, her way may be checked *on its approach*, which will give her an easier passage over it.

On Running before a Broken Sea or Surf to the Shore.

The one great danger when running before a broken sea is that of *broaching-to*. To that peculiar effect of the sea, so frequently destructive of human life, the utmost attention must be directed.

The cause of a boat's broaching-to when running before a broken sea or surf is, that her own motion being in the same direction as that of the sea, whether it be given by the force of oars or sails, or by the force of the sea itself, she opposes no resistance to it, but is carried before it. Thus, if a boat be running with her bow to the shore, and her stern to the sea, the effect of a surf or roller on its overtaking her is to throw up the stern, and, as a consequence, to depress the bow; if she then has sufficient inertia (which will be proportional to weight) to allow the sea to pass her, she will in succession pass through the descending, the horizontal, and the ascending positions, as the crest of the wave passes successively her stern, her midships, and her bow, in the reverse order in which the same positions occur to a boat propelled to seaward against a surf. This may be defined as the safe mode of running before a broken sea.

But if a boat on being overtaken by a heavy surf has not sufficient inertia to allow it to pass her, the first of the three positions above enumerated alone occurs—her stern is raised high in the air, and the wave carries the boat before it on its front, or unsafe side, sometimes with frightful velocity, the bow all the time being deeply immersed in the hollow of the sea, where the water being stationary, or comparatively so, offers a resistance, whilst the crest of the sea, having the actual motion which causes it to break, forces onward the stern or rear end of the boat.

A boat will, in this position, sometimes aided by careful oar-steering, run a considerable distance, until the wave has broken and expended itself. But it will often happen that if the bow be low, it will be driven under water, when the buoyancy being lost forward whilst the sea presses on the stern, the boat will be thrown (as it is termed) end over end; or if the bow be high, or it be protected as in most life-boats by a bow air-chamber, so that it does not become submerged, then the resistance forward, acting on one bow, will slightly turn the boat's head, and the force of the surf being transferred to the opposite quarter, she will in a moment be turned round broadside by the sea, and be thrown by it on her beam-ends, or altogether

capsized. It is in this manner that most boats are upset in a surf, especially on flat coasts, and in this way many lives are annually lost amongst merchant seamen when attempting to land after being compelled to desert their vessels.

Hence it follows that the management of a boat when landing through a heavy surf, must, as far as possible, be assimilated to that when proceeding to seaward against one, at least so far as to stop her progress shoreward at the moment of being overtaken by a heavy sea, and thus enable it to pass her. There are different ways of effecting this object:

1. By turning a boat's head to the sea before entering the broken water, and then backing in stern foremost, pulling a few strokes ahead to meet each heavy sea, and then again backing astern. If a sea be really heavy and a boat small, this plan will be generally the safest, as a boat can be kept more under command when the full force of the oars can be used against a heavy surf, than by backing them only.

2. If rowing to shore with the stern to seaward, by backing all the oars on the approach of a heavy sea, and rowing ahead again as soon as it has passed to the bow of the boat, thus rowing in on the back of the wave; or, as is practiced in some life-boats, placing the after-oarsmen with their faces forward, and making them row back at each sea on its approach.

3. If rowed in bow foremost, by towing astern a pig of ballast or large stone, or a large basket or canvas bag, termed a "drogue" or drag, made for the purpose, the object of each being to hold the boat's stern back, and prevent her being turned broadside to the sea, or broaching-to.

A boat's sail bent to a yard, and towed astern loosed, the yard being attached to a line capable of being veered, hauled, or let go, will act as a drogue, and tend much to break the force of the sea immediately astern of the boat.

Heavy weights should be kept out of the extreme ends of a boat; but when rowing before a heavy sea, the best trim is deepest by the stern.

A boat should be steered by an oar over the stern, or on one quarter when running before a sea, as the rudder will then at times be of no use. If the rudder be shipped, it should be kept amidships *on a sea breaking* over the stern.

The following rules may therefore be depended on when running before, or attempting to land through a heavy surf or broken water:

1. As far as possible avoid each sea, by placing the boat where the sea will break ahead or astern of her.

2. If the sea be very heavy, or if the boat be very small, especially if she have a square stern, bring her bow round to seaward and back her in, rowing ahead against each heavy surf that cannot be avoided sufficiently to allow it to pass the boat.

3. If it be considered safe to proceed to the shore bow foremost, back the oars against each sea on its approach, so as to stop the boat's way through the water as far as possible, and if there is a drogue, or anything in the boat that may be used as one, tow it astern to aid in keeping the boat end-on to the sea, which is the chief object in view.

4. Bring the principal weights in the boat toward the end that is to seaward, but not to the extreme end.

5. If a boat worked by sails or oars be running under sail for the land through a heavy sea, her crew should under all circumstances, unless the beach be quite steep, take down the masts and sails before entering the broken water, and take her to land under oars alone, as above described.

If she have sails only, her sails should be much reduced, a half-lowered fore-sail or other small head-sail being sufficient.

Beaching or Landing Through a Surf.

The running before a surf or broken sea, and the beaching or landing of a boat, are two distinct operations; the management of boats, as above recommended, has exclusive reference to running before a surf where the shore is so flat that the broken water extends to some distance from the beach. Thus on a very steep beach, the first heavy fall of broken water will be on the beach itself, whilst on some very flat shores there will be broken water as far as the eye can reach, sometimes extending to even four or five miles from the land. The outermost line of broken water on a flat shore, where the waves break in three or four fathoms water, is the heaviest, and therefore the most dangerous, and, when it has been passed through in safety, the *danger lessens as* the water shoals, until on nearing

the land its force is spent and its power harmless. As the character of the sea is quite different on steep and flat shores, so is the customary management of boats, on landing, different in the two situations. On the flat shore, whether a boat be run or backed in, she is kept straight before or end to the sea until she is fairly aground, when each surf takes her further in as it overtakes her, aided by the crew, who will then generally jump out to lighten her, and drag her in by her sides. As above stated, sail will, in this case, have been previously taken in if set, and the boat will have been rowed or backed in by oars alone.

On the other hand, on the *steep* beach it is the general practice, in a boat of any size, to retain a speed right on to the beach, and in the act of landing, whether under oars or sail, to turn the boat's bow half round toward the direction from which the surf is running, so that she may be thrown on her broadside up the beach, when abundance of help is usually at hand to haul her as quickly as possible out of the reach of the sea. In such situations we believe it is nowhere the practice to back a boat in stern foremost under oars, but to row in under full speed as above described.

Carrying Stores.

Do not overload a boat, particularly with men or sand. Sand is much lighter when dry than when wet. Keep all casks "bung up" and leave space aft for baling out the boat. Have tarpaulins for covering stores. When loading, make large allowance for the roughness of the water you may have to encounter.

Remember that a laden boat carries her way longer than a light one, therefore shorten sail or stop rowing in time.

In a tideway, do not forget what may be done with a warp.

If sent for treasure, always have a net or canvas bag to contain the treasure, and a buoy rope to attach to it to recover it in case of accident.

Towing.—In taking another boat in tow, pass clear of her oars, place yourself ahead exactly in line, and give way as soon as you have the tow-line. Toggle the tow-line a little forward of the stern, so as to be able to bear it over the quarter to assist in turning, as your helm alone will be of little use. The heaviest boats should be *nearest the tow.* Boats will tow with increased effect if weighted;

shot or a few lengths of stream-chain may be quickly passed in for such a purpose. Do not give another boat your painter until she is right ahead.

To tow boats in any vessel above the height of a flush deck, the tow-rope should be from forward. This precaution adds much to the safety of boats towed beyond their own speed. If you tow from forward, and your ship is "by the wind," the boat can be kept under the shelter of the lee-quarter, and still have a good scope of tow-rope. Boats towed from forward can be quickly prepared for service. The line should be kept ready for slipping.

Running Warps.—On taking in the end of a warp, coil enough of it forward, so as to be able to make a bend the instant your boat reaches the place where the warp is to be made fast. In laying out a heavy warp, it is best to float its bight. A quick way to run out a warp, is for one boat to run away with the end and the other to pull in fore and aft under the bights as they are paid out, giving way the moment they have hold.

Guess Warp.—The whole warp is sometimes coiled in the boat, and the end being made fast to some desirable place, the boat makes for the ship. In other cases a part only is coiled in the boat and she carries it from the ship to the make-fast, paying out as she goes. In either case judgment is required in reserving enough line in the boat to ensure her reaching her destination. Wind and tide being favorable, take the warp in the boat, pull to windward, and run from make-fast to ship. *Wet warps require very careful seizings.*

Boat Standing for the Ship and Unable to Fetch Up.—When a boat is unable to pull up against a lee tide, or against a strong wind and sea, veer a line astern with a buoy or breaker on the end, and a second, and even a third buoy will serve to float the bight and carry the line more quickly. When the weather will admit, this service may be quicker done by sending a boat to carry the end of the line to the boat in distress, and haul both up together, the boats giving way at the same time.

Caught in a Fog.—If after towing a ship out of harbor you should be caught in a fog, go on board the ship you have been towing, take the bearing of the port, known by the course steered, or the relative *direction of the wind* if it is steady, and shove off, keep-

22

ing the ship on the proper bearing as long as possible till you get in shore. The lead must be kept going, and the soundings will tell you if you are nearing the shore. The ship may also heave-to and fire guns at intervals, till you have time to get into port.

To Set Fire to a Ship or Buildings.—If sent away on this service, take with you a lighted slow-match and port-fire. If you are away without either, the quickest way to make a fire is by mixing a couple of cartridges up into a *devil*, and setting fire to it by means of a piece of paper smeared with wet powder, fired out of a rifle with reduced charge. A cap, struck with a knife, having a piece of touch-paper in it will do if the report of a rifle would be inconvenient.

General Duties.—A boat may be got upon a beach easily by placing stretchers or thwarts under the keel; of course rollers are better.

If you have tackles, you can get a pull by burying your anchor, keeping a hand on it to prevent it from rising. All boats should have a hole in the fore-foot, through which a strop for the tackle can be rove.

Sea-weed acts like soap on the ways.

When weighing anything heavy over the stern, have the rope amidships, and secure it there to prevent slipping.

To get a boat under a low bridge or like obstruction, take out the plug until she can go under.

When sent to land parties on a shallow beach, take a howitzer-carriage and some light planks; by hauling the carriage between the boat and the beach, you may lay a platform from one to the other, and rig a temporary jetty.

The field-carriage also makes a good "devil-cart," and buried, with one wheel and axle left above ground, may serve as a capstan by lashing oar-looms on the spokes.

When there is a rise and fall of tide, great weights, such as a gun for example, may be got into a boat by filling the boat at low water with sand, banking up an inclined plane with shingle, rolling the gun into the boat, clearing out the sand, and allowing the tide to float her off.

The best way to transport on land a moderate-sized boat, is to *turn her bottom up* and shoulder her.

A forty-two foot launch will carry in bulk, in smooth water, about twenty tons of water.

In rafting casks, knock the inner hoop off each end, and drive it on again over a sennet-becket; stop the raft-line to these beckets, but do not reeve it, as the casks can thus be more readily detached.

In anchoring a boat on rocky ground, bend the cable to the crown of the anchor, and stop it to the ring before letting go; then, if the flukes jamb, the stop will carry away, and the anchor may easily be weighed.

Creeping for Anchors.

When a cable has parted, or has been slipped, and there is no buoy, it may be "crept for" in the direction of the compass bearings.

Boats having a rope with the bight weighted, which keeps it on the bottom, row on parallel courses some distance apart. When the rope comes in contact with the flukes of the anchor, the boats cross each other's course; a hawser is hauled round the fluke by means of the creeping-rope; an anchor-shackle is then put on both parts of the hawser, and allowed to run down to the anchor to jam the parts together to prevent the hawser from slipping off when weighing the anchor.

The best way to row is in line with the shank, and perhaps a small chain will be found more efficient than a line for creeping. If there be a tide, it will save trouble to lay out two kedges, by which the boats can be warped to and fro.

In creeping for a cable, two *fish-hooks* joined at the eyes, and kept apart with the hooks in the same direction by battens lashed across their backs, form an excellent creeper.

It is dragged by the eyes, and kept hooks downward by a small back-rope. A boat's anchor may also be used, but the back-rope must never be omitted, as it serves to clear it whenever entangled at the bottom.

Carrying Anchors Out by Boats.

With boats having tubes fitted for the purpose, the anchor is lowered down and the flukes hove up under the boat's bottom by two parts of a stout rope, the bight of which is around an arm of the anchor; the ends are led through the pipe and brought to the windlass.

The stock is hung horizontally from the stern.
Heavy guns may be carried in the same manner.

Stream-Anchor.—In carrying out the stream-anchor, receive it athwart the after part of the boat. Hoist it out by the ring; when the crown is below the gunwale, hang it with a rope from the bottom bolt around the arms, and then lower, bearing the stock over the opposite gunwale.

After the anchor is in place, bend on the cable (under the stock). If the anchor is very short, place a thwart across the stern, lay two capstan-bars fore and aft, and land the anchor fore and aft on this platform, flukes aft. If the anchor is fitted with slings, it can be handled with great facility.

Whenever the anchor is to be weighed again by a boat, put a block on the crown and reeve a double buoy-rope through it before letting go.

To Carry Out an Anchor by Boat when the Ship is on Shore.

If there be much wind or sea, first lay out a kedge to haul out by; let the boat carry along the end of a stout line, and after the kedge is let go, bend the end of the hawser to the line, when the hawser can be hauled in from the ship. Meanwhile rig the fish-davit; clap two strops around the outer arms of the anchor, and seize in two thimbles, through which reeve the end of the buoy-rope, and stop it along to the shank to keep it middled.

Put a long pair of slings round the shank before the stock, and lash to the upper end of the stock to keep it perpendicular. Pass a piece of rope round the shank, and stop its ends up the upper end of the stock.

Hook the *fish-tackle* to the inner arm from *aft* forward; hook the *cat* to the stock-slings and get the anchor out, keeping the stock perpendicular and shank horizontal, until it is about three or four feet under water.

Bring the stern of the launch against the stock, and haul her side close in to the fish; secure the stock of the anchor to the stern by the ring-stopper, passing the turns through all of the stern ring-bolts; bring the ends of the buoy-rope in taut on each side, through the row-locks, and secure the bights through the foremost ring bolts.

Ease up and unhook the cat and fish-tackles; stop a length of cable around the boat *outside*, and range as much chain in the bottom as it is necessary to carry out, stopping it at intervals and making the end *well fast*.

When about to let go the anchor, get a cast of the lead to make sure that you have cable enough outside the boat to reach bottom, and hang it to the stern that no more may run out.

Let go the anchor with the boat's bow *from* the ship, either cutting or slipping all lashings at once.

Lash a bar across the stern, and veer away the cable cautiously, fathom by fathom.

If the end of another cable be brought to you, shackle it, keeping the shackle outside the boat, and throw out the bight, letting both parts hang from the stern, and, when all clear, slip the bight.

Anchors should be laid out *before* lightening the ship, otherwise she may be driven further on shore.

When the boat is unequal to the weight, sling four casks in pairs, marrying and snaking the slings. Weigh the stern of the boat, and bear the casks underneath to increase the buoyancy of the boat. With a large boat so fitted, the anchor may be hung, with its stock horizontal, across the stern and more cable carried out. This is a quick method, but if the anchor be too heavy to carry in this manner, the flukes may be hove up under the bottom and secured as before.

Method with Two Boats.

Lower the anchor, stock horizontal, to the water and haul up the boats stern foremost, about the breadth of the palm of the anchor from each other, and on each side of the shank.

Hang the stock with slip-ropes from the after ring-bolts of the boats, over a spar lashed across their sterns. Another spar is lashed across the gunwale of both boats before the palm.

The spar must be chocked up at the gunwale, ends of thwarts, and amidships, from the keelson.

Secure the fluke of the anchor to the forward spar with a strop or toggle, or lashing handy for cutting. The cable may be bent and its bights borne by other boats as the launches haul out by the kedge. The buoy-rope should be under the spar to go clear.

Always take punches, pins and hammers in a boat when setting out on an anchor expedition.

Hemp or wire-cables are lighter and may often be used with advantage. Anchors weigh about one-tenth less in salt water.

Vessels may sometimes be gotten off by transporting anchors to the quarters and letting them go, carrying the cable to the bows and heaving in.

BOAT RACING.

The Following Rules, Drawn up for the Channel Fleet Regatta of 1872, may be found Useful in Future.

1. The sailing course to be triangular, and about six miles long. A special course (about four miles) will be made for single-banked boats. The long rowing course to be about two and a half miles; the middle course about one mile and three-fourths; and the short course one mile.
2. All buoys to be left on port-hand by rowing boats.
3. The direction in which sailing-boats start to be decided by the committee on the morning of sailing.
4. The committee reserve to themselves the power of altering or increasing the course, if requisite, or of altering the days for pulling and sailing according to the weather.
5. In all races, three boats to start, or no race.
6. In races where a second prize is given, four boats to start, or no second prize. When a third prize is given, six boats to start, or no third prize.
7. All objections to be lodged with the committee within half an hour of the objecting boat passing the winning-post. The decision of the committee to be final.
8. Entries to close at noon on the day before the regatta, and to be addressed to the Secretary of the Regatta Committee.
9. All boats to carry distinguishing flags, 17 × 14 inches.
10. Any additional funds will be added to the prizes or disposed of as the committee may decide.
11. In the service races, no boats to be allowed to use more than the regulation number of oars; the oars to be pulled from their proper thwarts, and in sailing-races service rigs to be adhered to; neither iron ballast nor false keels to be allowed. Water ballast only

permitted. " Service rig " is to be understood as the ordinary working rig of the boat.

12. In all service races ballast may be trimmed, but not started.

13. The officer who acts as a member of the committee to do his utmost to see that all boats of his own ship abide by the rules.

14. No member of the committee is allowed to pull or sail in a racing boat.

Programme.

First Day.—Rowing.		Second Day.—Sailing.	
No.	Races.	No.	Races.
1	Pinnaces. Long course.	1	All launches. One prize for steam, and one for other launches.
2	Gigs, 4 oars. Middle course.	2	Pinnaces.
3	All launches, 18 oars. Long course.	3	Cutters and barges over 28 feet.
4	Dingies, 4 oars. Short course.	4	Cutters, 28 feet and under.
5	Cutters and barges, 12 oars or less. Long course.	5	Life-boats.
6	Whalers and 5-oared gigs. Middle course.	6	Single-banked boats.
7	Launches, pulled by marines. Long course.		Champion copper punt race, no sails, to be paddled with shovels.
8	4 and 5-oared gigs and whalers, pulled by boys. Middle course.		Tubs without keels, duck hunts, etc.
9	Galleys and 6-oared gigs. Long course.		*Fancy dresses admissible.*
10	Cutters and jolly-boats, 8 or 10 oars. Middle course.		
	No boat entering for No. 5 can pull in this race.		
11	Dingies, pulled by marines. Short course.		
12	Cutters, 12 oars, pulled by stokers. Middle course.		
13	6-oared galleys, pulled by officers. Middle course.		
14	Cutters, 12 oars, pulled by boys. Middle course.		
15	All comers; boats may be double-banked. Long course.		
16	Consolation stakes for all boats that have raced, but won nothing.		

Additional Regulations drawn up for the Regatta of 1874.

1. In the service races, no boats to be allowed to use more than the regulation number of oars; the oars to be pulled on their proper thwarts (except in Nos. 5 and 8 Races).

2. The committee will give directions previous to the race on which hand the buoys are to be left.

3. An officer to be in all double-banked boats.

4. If the boat's crew are seamen, a seaman is to steer; if marines, a marine is to steer; if composed of stokers, a stoker is to steer.

5. Any boat purposely fouling another, or making use of the vessels or buoys stationed, as turning-points for the purpose of rounding more readily, will be disqualified.

6. All boats to be sailed by a full boat's crew.

7. All boats in the proximity of any boat that may capsize are to render immediate assistance, and such boats shall have the option of sailing the two winning boats, provided the committee are of opinion that the boats rendering assistance stood a chance of taking either of the prizes.

8. In the event of any boat capsizing in the early part of the race, the committee have the power of recalling all boats and starting them afresh.

9. Any boat using propelling-power, such as oars, balers, hands or feet in the water, to be disqualified.

10. The rules of the road with regard to meeting or passing, or giving way to one another, are to be strictly adhered to, and any boat purposely fouling another will be disqualified.

11. Any boat capsizing, both officer and boat shall be excluded from racing again for that particular prize.

First Day.—Rowing Races.

No.	Class of boats.	Maximum number of oars.	Maximum length in feet.	Course to be pulled.	By whom pulled.
1	Cutters	12	30	Long.	Seamen.
2	Whalers	5	—	Middle.	Midshipmen.
3	Launches	18	42	Long.	Seamen.
4	Dingies	4	—	Short.	Boys.
5	Cutters	12	28	Long.	Marines.
6	Galleys	6	—	"	Seamen.
7	Pinnaces	14	32	"	"
8	Cutters	12	23	"	Stokers.
9	Whalers and gigs	5	—	Middle.	Boys.
10	Launches	18	42	Long.	Marines.
11	Cutters	10	28	"	Seamen.
12	Whalers and gigs	5	—	Middle.	"
13	Cutters	8	23	"	"
14	Cutters	12	30	Long.	Boys.
15	All comers, in service boats; oars may be double-banked	—	—	Long.	Seamen, Stokers, and Marines.
16	Consolation stakes, for boats that have raced and won nothing	—	—	Middle.	Seamen, Stokers, and Marines.
17	Service boats belonging to their own ships	—	—	"	Officers.

Second Day—The same races as in 1872.

SOUNDING, NAUTICAL SURVEYING, ETC.

SOUNDING is especially work for the sailor, requiring all the ready wit and tact of his profession.

In a detailed survey of a harbor, the hydrographic work will be made more complete and symmetrical by the adoption of a plan of sounding lines prior to the commencement of the work.

The selection of the plan is determined by the degree of accuracy required, the time which may be given to the work, the number of observers, *and the conditions* of winds, weather and currents.

A vessel may at times be anchored in a bay or off a coast of which no chart exists; in this case it may be considered necessary not only to sound round the ship, but to be able to make some report upon the anchorage. If, therefore, circumstances prevent a regular survey of the place being made, some idea of its form, extent, and depth of water may be arrived at by simply running lines of soundings from the ship anchored near the centre, to the prominent points, noting at these points the mast-head angle, taken both on and off the arc, and the compass-bearing of the ship.

In such a case a flag should be hoisted close up to the ship's main-truck, to facilitate the taking of the mast-head angle, and the following practical hints may be found useful.

The instruments by the help of which the important operation of sounding is carried on, are the sextant, and lead and line.

The Sextant.—The sailor should lose no opportunity of making himself thoroughly conversant with this invaluable instrument, understanding all its adjustments, peculiarities, causes of error, the size of angle to be safely measured with it, and the means of re-quicksilvering its reflectors.*

When in port, lying at anchor, a simple exercise in using the sextant is to take a round of angles, consisting of six or more, between distinctly seen objects lying nearly in the same horizontal plane, and see how near their sum may be brought to 360°.

Handle the sextant both ways, inverted as well as direct; circumstances may prevent some objects being reflected from right to left

---

* Admiral Sir E. Belcher gives the following detailed directions for resilvering sextant glasses when injured by damp or wet:

"The requisites are clean tin-foil and mercury—a hare's-foot is handy. Lay the tin-foil, which should exceed the surface of the glass by a quarter of an inch on each side, on a smooth surface (the back of a book), rub it out smooth with the finger, add a bubble of mercury about the size of a small shot, which rub gently over the tin-foil until it spreads itself and shows a silvered surface; gently add sufficient mercury to cover the leaf, so that its surface is fluid. Prepare a slip of clean paper the size of the tin-foil. Take the glass in the left hand, previously well cleaned, and the paper in the right. Brush the surface of the mercury gently to free it from dross. Lay the paper on the mercury, and the glass on it. Pressing gently on the glass, withdraw the paper. Turn the glass on its face, and leave it on an inclined plane to allow the mercury to flow off, which is accelerated by laying a strip of tin-foil as a *conductor* to its lower edge. The edges may, after twelve hours' rest, be removed. *In twenty-four* give it a coat of varnish, made from spirits of wine and red sealing *wax.*"

and the left-hand object that can be reflected must in such cases be used.

If angles are taken between two objects close to each other, care should be taken that they are in the same horizontal plane, or nearly so, with large angles; the error caused by obliquity is in these cases small.

Every opportunity should be taken of fixing the position of the ship on the chart by bearings and angles.

If there is a chart of the harbor, it is good practice to take angles to the different points, peaks and islets, and, laying the same off from the ship's position, to see if they agree with those on the chart. True bearings of objects, both right and left of the sun, should be frequently observed, taking care that the angle measured between the sun and the object is at least double the altitude of the sun.

The arc of excess in most sextants is 5°, and it is well to measure small angles off, as well as on the arc; observed mast-head angles, and angles taken to peaks on making the land, will generally be less than 5°. Taking the angles off and on the arc, adding them together and dividing by two, gives an angle free of index error. At sea, measuring the sun's semi-diameter, and comparing that obtained with that given in the "Nautical Almanac," is excellent practice. If an object is clear and well defined, the inverting-tube will be found of great assistance.

Laying out targets in well-known harbors or roadsteads by the mast-head angle, taking the angle both on and off the arc, is good practice for the method used for determining an approximate base in nautical surveying. When the target is moored, if time permits, get a round of angles from it; these plotted on the chart of the harbor will afford an opportunity of testing the accuracy of the base obtained from the mast-head angle.

The Lead-Line.—In addition to its use in sounding, the lead-line may also serve, in the absence of a chain, for measuring a base-line or ascertaining the height of a cliff. A ship's line that has been some little time in use, and is well-stretched, should be used for this purpose, marking it, when wet, to feet as far as five fathoms, having two knots at twenty feet and a piece of leather at twenty-four feet, or four *fathoms.*

The line should always be measured on the nails driven into the quarter-deck for that purpose, both when leaving and returning to the ship, taking care that the line is always thoroughly wet.

If obliged to use a new line, provision for frequent remeasurement of the line in the boat should be made, by having the boat-hook marked to feet for that purpose. The lead-line should always be marked from the heel of the lead.

Men should be accustomed to heave the lead from the boats, and should be carefully watched when first at work, in order to ensure their giving correct soundings. Some little practice is required to determine: first, when an "up and down" cast can be obtained without laying on the oars, and, secondly, when it is necessary to stop the boat altogether. An awning-stanchion shipped, forms a good support for the leadsman's breast-rope. The end of the line should always be secured before beginning to sound, and the lead should be "armed" with tallow, as the nature of the bottom should always be noted.

Sounding in a tideway, it may be necessary to anchor the boat to obtain the mast-head or other angles to fix the boat's position.

Equipment of Boat.—A spare hand should be taken for sounding, and the following gear will be required:

Sextant, compass; if available a patent log, fitted so that the box part may be lashed on to the gunwale of the boat, a long fly-line being used.

Two leads and lines, the latter marked to feet as far as five fathoms, and one line being forty fathoms long; the leads to weigh, one seven pounds and the other fourteen pounds.

Anchor, with cable of thirty fathoms. Yoke-lines very long, to allow of the boat being steered by the feet if necessary. Bag of lime, whitewash brush, bucket and baler.

Matches and slow match; strand of junk for stops. Old canvas or black bags to make marks on shore. Tallow for arming leads. Two pigs of ballast or slung-shot for mooring buoys. An axe and crow-bar.

Two boat's breakers, one filled with water and the other fitted as a buoy.

Note and sketch-books, drawing-instruments and small board; telescope or binoculars; and a watch.

To Ensure the Lines Sounded upon Being Straight Lines.— The ship should either be kept in transit with some object beyond her, or some well-marked object should be found on shore in line with the point or mark for which it is intended to steer, this second mark lying sufficiently far behind the point steered for to show any deviation from the straight line required. If pulling or sailing to seaward, a range must be looked for astern; such objects being kept in line will *ensure* a straight course being followed. As there is some difficulty in steering by stern marks, their use should be made a point for practice.

In all cases the compass-bearing of the points steered for or from should be noted. Keeping the boat on known straight lines or ranges is the only sure method of sounding in a tideway, or through the varying currents of a harbor.

Running Lines.—The boat should be propelled at a steady rate upon the range, and the whole distance timed.

The soundings should be noted at equal intervals and distances. Under five fathoms the lead should be hove continuously, and the boat's position fixed by mast-head angle of the ship.

A space should be left underneath the soundings in the note-book, in which they may be reduced to low water by a table derived from tidal observations. The reduced soundings should be noted in red ink.

The time should be noted whenever soundings are taken, or at least every half-hour.

Attention in the notation of the time is not only a great assistance to the memory when plotting the soundings on a rough plan, but without it the reduction of the soundings to low water cannot be accurately carried out.

In sounding under sail, five fathoms may be obtained without lowering the sail, but if the water is deeper the sail should be lowered if running free, or the sheet "eased off" when sailing near the wind, to ensure getting an "up and down cast."

In using the boat's anchor in sounding, where the boat may be frequently anchored on rocky ground, it is advisable to bend the cable like a buoy-rope to the crown of the anchor, stopping it to the ring; then if the flukes jamb in the rock the stop will carry away, and the anchor may be weighed with ease. This precaution may

save the boat's anchor, and prevent any disarrangement of the contemplated scheme.

A BEACON may be contrived of a breaker, fitted as a buoy, with a buoy-rope of about ten fathoms of lead-line, and a pig of ballast to moor it by. This will be found useful to drop upon any sunken rock that may be discovered, the boat sounding around it in all directions to find out the extent and nature of the danger, carefully noting the courses steered, and estimating the distances passed over from and toward the beacon. When the existence of isolated rocks is suspected, sweeping should be resorted to, which will require two boats with a light line fitted with a chain bight. Dangers of this character, steep on all sides, will seldom be revealed by casts of the lead. Having determined the positions of such dangers, and the soundings over them, with care, it is also well to note the ranges which lead clear of them.

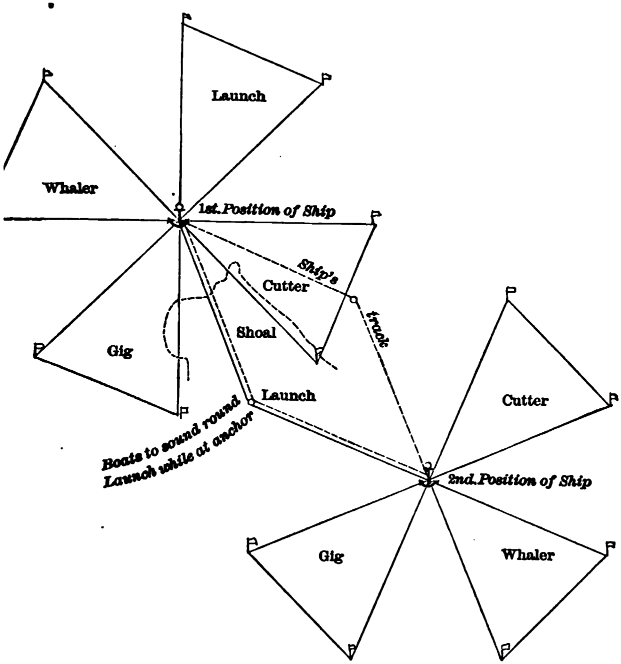
Note-Book.—The greatest care should be taken in entering the soundings, bearings, mast-head angles, time, and other matters in the note-book in such an intelligible manner that another person could use them, so that in case of accidents, common to seamen, if the note-book were saved the work would not be useless. On return to the ship, the work should be plotted as soon as possible, while everything is fresh in the memory.

ALL SOUNDINGS taken are to be reduced to the low-water level of ordinary spring tides.

Local Information.—If the bay or coast to be sounded is inhabited, important information may be obtained from the fishermen, as these men make their livelihood by their knowledge of localities useful to themselves, but dangerous to shipping, and are often able to point out the position of rocks or foul ground. Boats fishing should be avoided by a vessel coasting or entering a strange roadstead, as they are liable to be working in the vicinity of rocks or shoals.

Shoals out of Sight of Land.—If a shoal is fallen in with out of sight of land, or if a ship is sent to search for and examine a danger so placed, the vessel should, on finding the shoal water, if possible, anchor, mooring if convenient. Four boats might then be sent away *to sound on* north, east, south, and west lines from the ship for two *and one-half* miles, hoisting a flag every half-hour, and taking a

t-head angle of the fore-mast, at which truck a black ball should ıoisted, an observer at the ship at the same time taking a bear- of the respective boats. At the end of the two and one-half



ɜs, the distance should be determined by mast-head angle; the ts will then pull respectively E.S.E., S.S.W., W.N.W., and N.N.E., 1.9 miles, *fixing their positions* by mast-head angles, and hoist-

ing their flags to allow the ship to obtain bearings of them. They will then return to the ship on S.W., N.W., N.E., and S.E. courses, sounding and hoisting their flags as before.

If shoaler water be found, requiring further or more extended examination, the launch should be sent in the direction of the foul ground to anchor on a given bearing at a distance of not over two and one-half miles from the ship; a mast-head angle will be taken from the launch to determine the distance. Ship will weigh at a signal from launch, and take up a second position as convenient, not more than two and one-half miles from the launch, and another mast-head angle will be obtained from launch when ship has anchored and hoisted her mast-head flag or ball. Launch will return to ship sounding, and the three remaining boats should sound round the ship as before.

Geographical Position of Shoal.—The ship's position at one of her anchorages should be carefully fixed by astronomical observation; the latitude being determined, if possible, by meridian altitudes of stars north and south of the zenith. Time should be determined by equal altitudes, and a meridian distance obtained between the shoal and the nearest well-known point of land.

An approximate time of high water at full and change, together with the rise and fall of the tide, may be obtained by noting the depth alongside the ship with a well-stretched lead-line, carefully marked to feet and inches.

Plotting Soundings.—Positions may be plotted by means of an instrument called a *station-pointer*, but all soundings of great importance should be placed by geometrical construction.

The station-pointer consists of a graduated circle, to which three radial arms are attached, the central arm being fixed, and its edge coincident with the zero of the graduation. The other arms are movable, and have verniers arranged by which their edges may be set at any desired angle with the central arm. These arms being set to the observed angles, the pointer is placed on the chart with the edge of the central arm upon the middle station observed, and the edges of the lateral arms bisecting the positions of the other two observed objects. The centre of the instrument is then at the point of observation, which is marked upon the chart through the aperture provided for that purpose. Tracing-paper or linen, with a gradu-

ated circle, are good substitutes for the pointer. Soundings taken at equal intervals are very easily plotted by the use of a set of equidistant parallel lines drawn on tracing-paper, and separated by the distance on the chart-scale between any two soundings of a line. When the direction of the line is constant, it is only necessary to plot by the station-pointer the important soundings, and place the soundings between at equal distances.

To avoid the use of an unnecessary number of soundings on the finished chart, every second one may be omitted.

Contour-lines, or lines of equal depth, should be traced for every fathom up to three fathoms; or the same result may be effected by variations in the shading, making it lighter for each fathom up to three fathoms. If these lines can be drawn on the chart for all depths, without leaving any doubt as to their direction at any time, it may be taken as a sufficient test of the completeness of the soundings.

Reduction of Soundings.—As the soundings are taken at various stages of the tide, it is necessary to reduce them to a selected plane of reference. Soundings in all charts should be expressed by one uniform system, and should represent the depths reduced to the low-water level of ordinary spring tides, but as the requisite corrections for their gradual changes during the sounding work can only be applied by the subsequent comparison of the work in the boats with the simultaneous tide-column shown on the tide-gauge, the place of that gauge and the fidelity of its records will be points of prime importance; the establishment of the tide-gauge, and beginning a series of observations should, therefore, be the first step in every survey.

Bench Mark.—The soundings upon a chart give the depths of water above some selected plane of reference, usually that of *mean low-water*. To provide for the recovery of the plane of reference of the soundings at any time, as at a resurvey, it is necessary to fix the level of the plane of reference with regard to a permanent *bench*. Any object which is of a permanent character may be used as a bench. It should be marked by a circle with cross-lines at the centre, to indicate the exact position of the point of reference, and its location and elevation above the plane of reference should be described in the tidal record.

RUNNING ON SHORE.

On a vessel striking, throw the sails aback if on a wind, or clew-up and furl if before a wind.

A steamer will reverse the engines.

If on a sand-spit, it may be possible to force her over, but as a general rule she should be hove off as she went on.

Soundings must be obtained to ascertain the deepest water, and meanwhile the men may jump in the riggings to shake the vessel, or sally from side to side to aid the sails or engines in starting her. Weights may also be run aft, to change her trim.

If the first attempt with the sails or engines has failed to start her, however, an anchor should be carried out at once, *before starting weights*, and the cable hove well taut. Then the lightening may be commenced, observing to set well taut the purchases on the cable every time it slacks up. If the anchor comes home, back it with the stream, and, if necessary, send out another anchor on the opposite quarter.

With small vessels aground forward, sheers may be erected on the bottom, the legs reaching well above the bows, and the bows may then be *lifted* up by means of a heavy sheer-head purchase.

Vessels draw much less water when hove over on their beam ends than when upright. If the tide is falling, then the vessel must be shored up at once, and the spars may be assisted by sending out kedges on opposite sides, and bringing the hawsers in to the mast-heads, when they may be set taut as required.

If the tide rises, it will materially assist in getting the vessel afloat again.

Casks and water-tanks made water-tight may be used as camels to assist in raising a vessel clear of the sand.

Should an anchor be thoughtlessly dropped on the ship grounding, there is great danger of the ship striking on it and bilging.

Whenever badly on shore, bring the heaving-off cables in forward or amidships, but not over the stern, as they will tend to bear it down and press it on the bottom.

Leaks.—Upon springing a leak, man the pumps at once. In order to discover its locality, if unknown, steer on different courses. If it increases when going ahead, it is possibly forward; otherwise it

is aft. If there should be no change it may be on either side, which will be indicated, as before, by its increasing on one tack or the other.

Should the leak be near the water-line, the ship may be put about or listed, and it may be possible to cover it with sheet-lead or plank lined with felt, saturated with tar or tallow.

In other cases a sail may be "thrummed" with hot pitch and oakum, put over the bows, and hauled over the opening by guys.

As water enters as the square root of its altitude, the pumps may gain on the leak after the water has risen above it, although making but little progress at first.

Should a vessel be found to leak badly, she may, if in the neighborhood of land, be beached to prevent her sinking in deep water.

INFORMATION AND INSTRUCTION FOR DIVERS.

Siebe and Gorman's Patent Apparatus.

(*Bedford.*)

THE apparatus consists of a patent double-acting air-pump for supplying one or two divers with air; two men can work under a ship's bottom, independent of each other, from the same pump. By an ingenious arrangement with a lever, the supply of air can be thrown into one outlet from both cylinders, so that the one diver can work to a depth of one hundred and sixty feet, or twenty-six fathoms. When two divers work from the pump, they can with safety descend to ninety feet, or fifteen fathoms. The pressure-gauges denote the depth at which the divers are working.

The helmet is made of copper tinned, with a segmental neck-ring to unscrew the head-piece from the collar by one-eighth of a turn; lock-pin to prevent unscrewing; inlet and outlet valve; inflating arrangement, so that the diver can rise to the surface; and regulating cock, under control of diver, to regulate his supply of air. Four lenses; front, two side, and top-glass. The India-rubber dress is fastened to the helmet by means of brass-bands in segments, two front, two back, with screws and ring-nuts. A spanner is provided to fit the nuts for screwing tight the bands.

India-rubber dress made of tanned twill, with vulcanized collar and cuffs, *the collar forming* a water-tight joint on helmet-collar,

cuffs kept tight by flexible rings. Boots have lead soles, sixteen pounds weight each. Back and front lead-weights fitted to helmet with clips; weight of each forty pounds. There is a tackle used for protecting the stomach from pressure when diving in deep water. Leather belt with metal pipe-holder; knife in water-tight brass case, used for the diver to clear away ropes. The air-pipe is made of five-ply India-rubber and canvas, with spiral wire, imbedded, with gun-metal joints lashed in each, of forty-five feet and thirty feet lengths. The pipe stands pressure to one hundred pounds per square inch.

Care must be taken in dressing the diver; but when once under water the apparatus is self-acting, so that the man has only to think of the work he is going to perform.

Divers at the depth of thirty-two feet under water have upon the surface of their whole body a more than ordinary pressure of twenty thousand pounds weight, yet, when we consider the uniformity of that pressure, and its equability, which causes no dislocation of the parts, all the external being equally affected with it, and being internally supported by the air and other elastic fluids, which constantly endeavor to expand themselves as they are compressed —if we also consider the firm texture of the membranes and other solid parts of the human body, and the incredible force they are able to bear, as has been demonstrated by experiments—we shall not much wonder that divers complain of no sensible pain, though they be pressed with so great a weight of water, besides the ordinary pressure of the air which our bodies are continually exposed to, and which is equal to a depth of thirty-two feet of water, or twenty thousand pounds; so that the whole pressure to which a diver is exposed at thirty-two feet of water is forty thousand pounds, and in ratio as he descends.

The Following Table Represents the Pressure in Pounds on the Square Inch at a Given Depth of Water.

20 feet	8½ lbs.	90 feet	39 lbs.
30 "	12¾ "	100 "	43½ "
40 "	17¼ "	110 "	47¾ "
50 "	21¾ "	120 "	52¼ "
60 "	26¼ "	130 "	56½ "
70 "	30½ "	140 "	60¾ "
80 "	34¾ "	150 "	65¼ "

As to the effect of compressed air upon the lungs, and the general construction of the human body, scientific men vary; and, as we have no data from which we could form actual conclusions, we can only arrive at a result by the effect produced upon divers that have come under our notice. The first time a man descends under water he is ordinarily suffering from inherent nervousness, occasioned by the fact of undertaking a thing that has hitherto been unknown to him; consequently there is an increased pulsation and peculiar gasping for breath, and it happens in some cases to be so strong that it would be unadvisable, whilst in that condition, to allow them to descend, but rather, by making them acquainted with the working of the apparatus, and the example of teaching others to descend, to gradually remove the nervous weakness which attends many constitutions. When the nervousness is overcome, it would be advisable that they should descend slowly, swallowing their saliva, and not demanding too much air, resting at times to recover their equilibrium; and if the pressure should cause too great a pain in the head, by gently ascending a few feet it will gradually remove it, and the descent can be continued.

The rule as to coming up depends very much upon the constitution of the diver. A man at all sanguineous should ascend rather slowly; the brain being suddenly relieved from the pressure causes a suden rush of blood to the head, and it may cause unpleasant and serious consequences. We should advise a diver to ascend at a rate of not more than two feet every second—that is, for a strongly-constituted man. Nor should a diver, for at least two hours before commencing operations, take any food. If any kind of refreshments be required, a biscuit, with a small quantity of drink, or anything that will not excite the digestion, may be taken during the operations.

Instructions for the Dressing of Diver and the Management of Apparatus.

Previous to the diver being dressed, place the fly-wheel on crank-shaft, and fix the handles at right angles; oil the pistons with olive or neat's-foot oil, and also the bearings and other working parts; let the pump be worked for a few minutes; also pour some water into

the cistern to keep the cylinders cool, to prevent the air being heated and thus becoming rarefied. The piping should be laid on the deck, or place from whence the descent is to be made, in a serpentine form, so that the pipe does not kink. Remove the nut on air-nozzle and connect the air-pipe. The attendant should place his finger over the joint at the end of air-pipe, and let the pump work so that he can test the working of the air-pump's valves, and blow out any dust that may be in the pipes. If the water in the cistern becomes heated, it should be renewed.

Put on the Guernsey-frock; a pair of drawers and stockings, according to the temperature of the water; place helmet-cushion on shoulders, and tie the outside collar-piece round neck, and round each wrist place one or more vulcanized India-rubber rings. A piece of linen should be placed between the flesh and dress; the cuff-expanders should be used, so that the diver can pass his hand; then put on helmet-collar, place the vulcanized collar over the screws, put on the metal-plates, and screw the dress between moderately tight with the wing-nuts; be particular that the four nuts at joints are screwed up at the last. To keep the dress from chafing, put on large over-all stockings and canvas over-all dress, then the boots with lead-soles, and the leather-belt with pipe-holder and knife. The attendant should blow through the outlet valve of the helmet; he can do so by placing his head in the interior, and placing his mouth to the hole where the air escapes; blow strongly; if in proper working order, the valve will vibrate.

Connect air-pipe to inlet-valve; previous to doing so, pass it through the pipe-holder on belt, leading it under the left arm of diver; the signal-line to be fastened round the body, and to pass up the front of the right shoulder; the head-piece (without the front glass) can now be screwed on, which is done by one-eighth of a turn. Next attach the lead-weights, one behind and one before; the lines of the back weight pass over the loops on head-piece; the small line should be fastened to the lower corner of weights and round the waist with a slip-knot in front. The diver now being dressed, the air pump must be set in motion; when all is ready for the diver to descend, screw in the front glass.

To communicate with the diver when underneath the water by *word of mouth*, experiments have been made with very satisfactory *results, and are* now in operation.

LIFE-LINE.	AIR-PIPE.
1. All right.	1. Sufficient air.
2. According to diver's instructions	2. More air (pump faster).
3. " " "	3. According to diver's instructions
4. Coming up.	4. Haul up diver.

Divers' ladders are generally made of inch rope, with ash-rounds twenty-two inches long, and weighted at the end. Some divers have the ladder only twenty feet long, to the last round a rope with a weight attached, which rests on the bottom; by that means they descend.

All now being ready, let the diver descend, and when he reaches the bottom, before he leaves the ladder he must make fast a small leading-line to the ladder. The line should be coiled in the hand with a loop round the wrist, and as he leaves the ladder he lets the rope gradually uncoil, so that if he is any distance off he can find his way back to the ladder if he wants to ascend; but if by accident he loses the line, and is unable to find the ladder, he should make the signal to haul him up. In extreme cases the weights may be thrown off—that is, if he finds himself in any danger, and wishes to rise directly to the surface of the water; but this expedient should be seldom resorted to, as the signal for hauling up can always be given, and with presence of mind many difficulties can be overcome, when hurry and excitement may cause the loss of the diver's life.

The diver should seldom go forward; he must generally go backward; and if he meets with anything he must turn round and feel, particularly in the dark; but be careful to return the same way, otherwise he crosses the pipe and line; this precaution is very necessary. If entangled in the rigging, make use of the knife at side to clear himself away.

As some men require more weight to sink them than others, we would recommend them to make a shot-belt to buckle round the waist; it may be made any weight the diver may think necessary.

On the deck or place from where the diver descends, two careful confidential persons must attend the signal-line and air-pipe; they must attend them with the greatest vigilance, and keep them always moderately tight. If they should feel any irregular jerks which may be occasioned by falls or otherwise, they must haul him up immediately. The attendants on deck must from time to time give the signal *that all is right*, and if *the diver does not return the signal, he must be immediately* hauled up.

If the plungers of the air-pump or the other motions get slack, they must be screwed up with the spanners sent for that purpose, when the plungers will swell out a little; great care being taken that they are put in the same way as they are taken out, and all other parts of engine put together according to the marks. Always use olive oil for the air-pumps; if not to be got, use well-cleaned neat's-foot oil. When done working, and the engine is to be put by some time or lifted about, unscrew the plug at the lower edge of the back of the box and draw out the water, to prevent it washing over into the box or cylinders, or splashing the engine, or corroding the cistern if left standing. If the air-pump has been left standing by for any length of time, pour some warm water into the cistern, as it will warm the cylinders and soften the oil round the pistons, and the pump will work much easier.

To examine piston-valves, withdraw piston from cylinder. When the valve can be unscrewed to examine cylinder bottom-valves, lean the chest back and unscrew iron-plate on bottom of chest, and then unscrew the valve-bonnets; this arrangement avoids the trouble of removing engine from chest.

Be careful that the leather-washers are between the gun-metal joints, so that the air may not escape; also that the joints are screwed together moderately tight.

Should the water-proof dress, from constant use or accident, get leaky, it is easily repaired by laying two or three coats of varnish on each side of the seam, rubbing it with the finger as much as possible into the perforations made by the needle, allowing each coat to dry before the next is laid on; the sides of the seam may then be laid down, and two or three coats applied in the same manner to the channel of the seam, when the prepared strapping (which should have an extra coat laid on and dried) may be immediately applied, and well pressed down with the hand.

India-rubber diving-dresses should never be packed away in a wet or damp state; they must be thoroughly dried both in and outside before so doing, otherwise they will mildew, and become so rotten as to be of very little service afterward.

Should the dress and pipes be lying by for any length of time, and become hard, place them in a gentle heat, when they will become *quite soft.*

Section 7.

YACHTS AND YACHTING. MODERN TYPES.

PARTICULARS OF AMERICAN AND ENGLISH YACHTS.

STEAM-YACHTS. AMERICAN AND ENGLISH EXAMPLES.

SPARS, SAILS, ANCHORS, AND CHAINS.

NEW YORK YACHT CLUB SAILING REGULATIONS.

RULE OF MEASUREMENT, TABLE OF TIME ALLOWANCE, EXTRACTS FROM BY-LAWS, ETC.

SELECTION AND CARE OF YACHTS.

YACHTS' BOATS, ETC.

HANDLING AND CRUISING.

BALLOON SAILS.

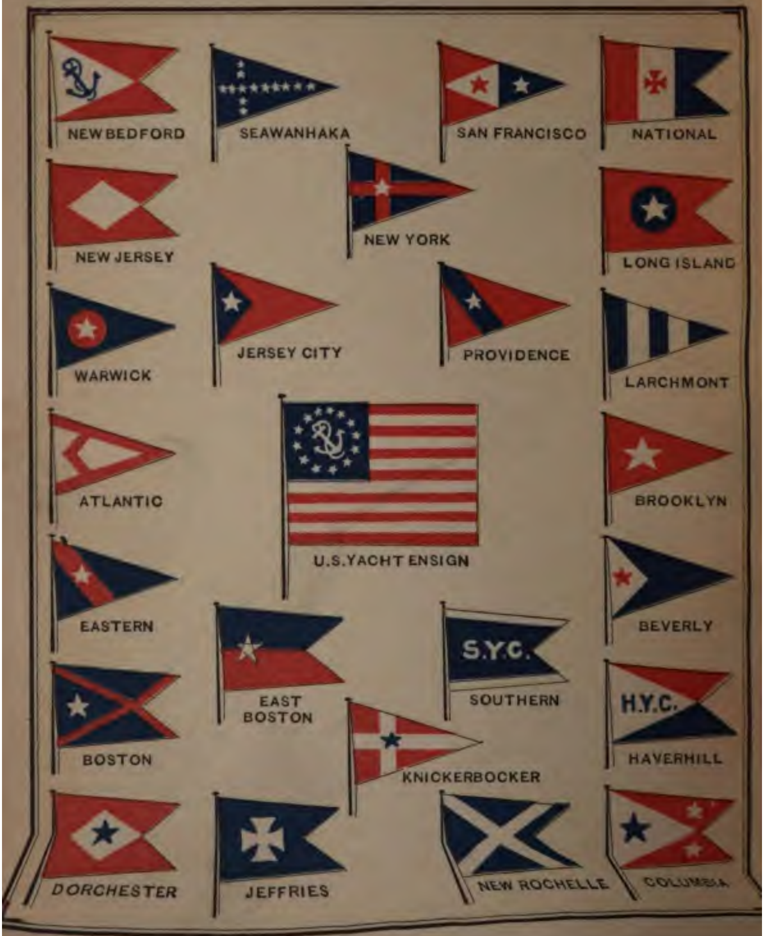
TEMPORARY RUDDERS, ETC.

RACING. VARIETIES OF STARTS.

EMERGENCIES, ETC., LAYING UP AND REFITTING.

QUESTIONS IN FORE-AND-AFT SEAMANSHIP.

AMERICAN YACHT CLUB SIGNALS.



AMERICAN YACHT CLUB SIGNALS.

YACHTS AND YACHTING.*

THE yacht fleets of the world have increased rapidly during the last quarter of a century, and at the present day those of Great Britain alone number over three thousand sail, employing over fifteen thousand hands regularly under pay, and having a gross tonnage of about one hundred and fifty thousand tons.

The fleets of America at present consist of over six hundred cabin-yachts, and nearly one thousand open boats of the jib and main-sail and cat-boat varieties. The total tonnage for 1881 may be placed at about twenty thousand tons, employing two thousand regular hands, and representing a value of over two million dollars.

During the past three years the popularity of the yawl and cutter-rigs has developed and the leading clubs have several each of these handy vessels.

Modern Types.

The present tendency, in America, seems to be to devise a mean between the extreme types representing the customary practice in Great Britain and this country.

The British yacht is the outgrowth of the old Thames rule of measurement, and of the demand for capable qualities of all kinds in rough water. It has great length and depth in proportion to its beam, and has much of the ballast in lead on the keel.

The sea-going qualities of vessels of this type are of the highest order, and leave little to be desired. They are fast in light winds and in heavy weather, and are uncapsizable, having their greatest range of stability when on their beam-ends.

The objections to such vessels are their great first cost; their excessive heeling; and their great draft of water. Their great first cost, however, arises from the excellence of their build—the use of the best material, copper-fastenings, hard-wood trimmings, a com-

---

* Much of the information concerning American yachts has been furnished by Mr. C. P. Kunhardt, N.A., and all of the matter relating to the New York Yacht Club, by Mr. Charles A. Minton, secretary of the club.

plete outfit in every way, and the use of lead as ballast. As lead is now used in all first class yachts in this country, the expense attaching to British yachts is due rather to their superior quality than to consideration of model. Their excessive heeling takes place only in strong lower-sail winds, in light weather or when reefed down they are sufficiently stiff.

In the matter of draft, a liberal amount is a disadvantage only under special circumstances.

The normal condition of centre-board yachts is with the boards down, when they actually draw more water than keel vessels. There are times when the option of raising the centre-board is an advantage, but these occasions are rare enough to question the advisability of foregoing the advantages of the fixed keel, including the low position of the outside ballast; better performance in open water; stronger construction; and increased accommodation.

Of late years, a gradual change in the direction of more depth has been showing itself in this country, although the wide light-draft boats still prevail.

The chief recommendations of the latter type are great stiffness and comfort; cheap first cost (with iron ballast); quickness in stays; great speed in strong lower-sail winds in smooth water; and the option of raising the centre board.

The objections to these vessels are both numerous and weighty.

They are hard on their helms, require large sails to drive them, and are easily capsized in squalls or through inattention; they are unreliable in stays in rough weather, are poor sea-boats, and, as usually constructed, have little deck room.

They are slow in light airs, and leewardly in a seaway, being capable of working to windward only against long easy swells. Owing to their large draft with the board down, there is danger of twisting the latter in shoal water, and the trunk is liable to give trouble on account of leaking. This type of yacht is expensive in wear, and comparatively short-lived.

In general, owing to the diversity of model and scantling, and the

habit of over-sparring, the ballast carried by American yachts varies very much in vessels of the same tonnage.

A design which shall be a compromise, in which the points of excellence of both the British and American types shall be represented, and liable to none of their weaknesses in a great degree, seems to be the popular demand at present.

Rigs.—The sloop-rig, which has always been much in favor in this country, is not adapted for yachts of fair tonnage, its unhandiness necessitating large crews, and being dangerous in heavy weather. In yachts of from forty to seventy-five feet in length, the adoption of the cutter or yawl-rig gives the necessary control over the canvas, and insures good sailing results. The number of cutters and yawls is increasing very rapidly, and the latter rig has almost superseded the sloop in the San Francisco Yacht Club. For cruising, these rigs are safe and snug; the vessel is always under control while making and taking in sail; and small crews may be carried.

For large yachts, the schooner-rig has always had the preference in American practice.

Particulars of Some American Yachts.

CUTTERS.

Name.	Length over all.	Length on water line.	Beam.	Draft.	Depth.	Draft with board.
Comfort	36	30.2	12	5	5.1	Keel.
Hesper	54	45	15.2	7	7.3	14
Muriel	45.6	40.6	9.2	7.9	6.3	Keel.
Volante	45	39.11	12	6.11	5.10	"
Vindex	62.5	56.5	17.3	8.9	7.9	"

Particulars of Some American Yachts.—*Continued.*

SLOOPS.

Name.	Length over all.	Length on water-line.	Beam.	Depth.	Draft.	Draft with board.
Active	55.6	50	16.6	5.6	4.6	11
Addie	64.2	56.6	17.4	5.1	4	11
Alpha	49	43	13	5	3.6	10
Annie	50	45.6	17.6	4	3.9	9
Arrow	66.6	61.8	20.2	6.6	5.6	18
Bloodhound	58.6	54	16.6	5.6	4.6	12
Coming	61.4	56.10	20.5	5.2	4.2	15
Corsair	47.5	42.9	17	6	4	13
Drift	53	48	18.3	6.3	4.3	16
Egeria	49	42.9	15.6	4.8	3.1	12
Elaine	52.6	52	18	5	5	12
Elephant	36	33	12.6	4.9	3.1	10
Ella Treadwell	48	41	15.6	4.1	4.2	12
Eolus	45	33.4	15	5	4.6	12
Eugenie	40.5	37.10	15.3	5.6	5.9	Keel.
Fanny	72	66	23.9	6.9	5	17
Flyaway	33.1	31.1	11.4	4	3	10
Gael	32.6	27.8	10.7	4.6	4.1	Keel.
Genia	47.6	39	14.6	4.8	4.4	11
Glance	47.8	45.5	14	4.7	4.8	Keel.
Gracie	79.10	60.9	21.6	6.8	6.6	15
Haswell	53.6	49.9	18.6	4 4	4.6	11
Imperia	46.6	40.6	15.3	5.2	4.3	11
Kaiser	45	41	14	4.10	3.9	9
Kate	56	48	18.5	4.3	4.6	11
Madcap	47	42	15	4.6	3.9	13
Mischief	67.5	61	19.10	7.9	5.4	15
Orion	51.2	46	15.1	5.2	4.8	12
Psyche	55.2	49.11	14.9	5.3	5.3	Keel.
Qui Vive	44.1	39.8	14.4	4.5	3.3	10
Ray	52.5	47.3	14.1	5.4	7	Keel.
Sadie	50	46.1	16.2	6.3	5.3	12
Schemer	39.1	36.4	14.6	4.6	3	14
Sunbeam	26.7	24.6	10.3	4	5	Keel.
Undine	55.8	49	17.6	5.4	4.9	14
Vanitas	34.9	27.6	12.2	5.1	5	Keel.
Violet	35.6	32.3	13	5.9	3.1	9
Vision	72	60.2	20.2	6.1	4.10	14
Vixen	51.1	44 1	16	5	4	11
White Wing	40	35	14.4	4.6	3.9	10

Particulars of Some American Yachts.—*Continued.*

SCHOONERS.

Name.	Length over all.	Length on water-line.	Beam.	Depth.	Draft.	Draft w. board.
Alarm	121.8	112.2	24	9	11.3	Keel.
America	100.6	90.6	22.6	9.3	11.6	"
Caroline	53	45	15.3	7	6.9	"
Clio	76.4	67.1	18.6	6	5	18
Clytie	85	78.3	21.7	8.3	7.7	18
Columbia	107.9	96	25.1	8.4	6	22
Consuelo	59.9	55.9	18.4	4.3	4.4	10
Cornelia	65.8	55.2	17	6	4.8	10
Crusader	88.7	78	21.6	8.3	7.6	18
Dauntless	120.9	116.5	24.9	9.9	12	Keel.
Dreadnought	130.3	115.9	24.5	9.8	11.4	"
Ermengarde	100.2	91.2	18.7	9	10.3	"
Estelle	88	78.5	22.9	6.5	6.6	15
Eva	73.6	66.1	22.4	5.9	5	14
Fearless	58.3	54.3	16.5	5.9	6	14
Fleetwing	108	95	23.4	10	10.6	Keel.
Foam	82.5	76	21	7	6.1	14
Frolic	56	49	15.8	7.4	7.8	Keel.
Halcyon	82	79	23.9	7	6	17
Idler	96.2	87.6	23.4	8.5	6.8	18
Intrepid	116.3	100.9	24.5	11.6	11.6	Keel.
Madeleine	106.4	95.2	24	7.9	7.4	19
Magic	81.8	78.11	20.9	6.3	6.7	17
Meta	76	62.6	19.6	6.6	5	13
Mohawk	140	121	30.4	9.4	6	31.6
Norna	114	95	20.6	10.6	11.3	Keel.
Palmer	110.9	104.3	24.2	10.3	9.9	20
Peerless	75.2	66.3	18.10	6.4	5.9	13
Phantom	100.8	86	24.11	7	6.6	17
Rambler	138.11	128.6	25	9.7	11.5	Keel.
Republic	96.6	78.6	23	9.3	7.6	18
Restless	81	73.6	20.2	7.9	8.2	Keel.
Sappho	135	119.4	27.4	9.6	12.8	"
Satoria	61	55.5	18	7.9	7	"
Silvie	82.9	74.7	24.3	6.6	6.5	16
Southern Cross	73	65	18.6	7.9	7	16
Viking	101.9	86.4	23.5	8.2	6.5	18
Wanderer	118.3	106.2	23.3	8.6	10.5	Keel.
White Cap	73	65	20.6	8.6	9	"

Area of Lower Sails.

America	5,263 square feet.	Mohawk	10,500 square feet.
Columbia	8,000 "	Sappho	10,223 "

Ballast.

	Tons.			Tons.	
America	45		Southern Cross	7	
Caroline	6.5	(2¼ tons lead on keel.)	Æolus	7	
Columbia	35		Arrow	23	
Crusader	28		Comfort	5	(1 ton iron on keel.)
Frolic	16	(2½ tons lead on keel.)	Elephant	7	
Intrepid	65	(25 tons lead on keel.)	Fanita	14	
Mohawk	40		Mischief	27	
Republic	27		Regina	13	
Sappho	80		Sunbeam	3.5	

Particulars of Some Modern British Yachts.

Name.	Rig.	Length on load line.	Beam.	Depth.	Mean draft to rabbet.	Extreme draft.	Displacement.	Area of lower sails.
							TONS.	SQ FT.
Aline	Schooner	100	20.9	11.3	9.4	11.6	190	6,710
Arrow	Cutter	72.8	18.3	8.2	7	11.5	107	4,680
Bloodhound	"	59.8	12.1	7.8	7	9.4	47	2,620
Cambria	Schooner	100	20.5	11.6	9	12.4	167	6,418
Egeria	"	93.7	19	10.1	9.8	12.5	142	5,988
Florinda	Yawl	85.7	19.1	10.8	9.4	11.9	144	5,257
Fiona	Cutter	73.5	15.8	9.6	8.6	12.2	108	3,720
Freda	Schooner	50.8	9.8	9.6	7	9	35.5	1,980
Guinevere	"	121	23	13.3	11	12	297	8,611
Gwendolin	"	100	20.5	12.3	10.6	13	202	6,963
Heathen Chinee	Sloop	18	7	4.9	2.8	4.2	3.5	335
Jullanar	Yawl	100	16.8	13.1	7.8	13.8	158	4,988
Kreimhilda	Cutter	79.3	17.3	11.1	10	12.3	115	4,405
Lily	"	36.6	8	7.4	4.6	6.8	12.9	1,095
Livonia	Schooner	107.5	23.3	11.9	10.8	12.8	215	7,618
Madcap	Cutter	44.8	10.1	6.9	6.3	7.5	27	1,700
Miranda	Schooner	88.5	18	12.7	11.2	12.4	149	5,800
Sea Belle	"	90.5	18.9	11.6	10	12	155	5,785
Vanessa	Cutter	47	9.8	8.2	6.1	7.8	28.5	1,732

Ballast.

Arrow	*40 tons.*	Florinda	52 tons.	Jullanar	80 tons.	Pastime	8.4 tons.
Bloodhound	*26* "	Freda	19 "	Lily	6.8 "	Sea Belle	73 "
Cambria	*65* "	Gwendolin	90 "	Livonia	70 "	Vanessa	16.5 "

Particulars of Some American Steam-Yachts.

Name.	Built.	Length over all.	Length on water-line.	Extreme breadth.	Depth.	Greatest draft.	Engines.	Diameter of screw.	Pitch of screw.	Boilers.	Rig.
		FT.	FT.	FT.	FT.	FT.	IN.	FT.	FT.	FT.	
Bretagne † ..	1880	240	210	32.5	19	14	C.I. 28 & 50 x 33	13*	21	Two 12 x 10 x 13	Barque
Corsair ‡	1880	185	165	23.8	14	10.5	C.I. 24 & 44 x 24	9	13	Two 10.5 x 11	Schooner
Gleam §......	1880	120	110	16	6.5	—	C.I. 10.5 & 18 x 18	—	—	Patent coil 5⅜ ft. diam.	—
Henriette † ..	1880	205	164	26	—	12	C.I. 45 & 38 x 40	10.5	16	—	—
Ideal ‖.......	1874	130	110	8	8	7	—	—	—	—	Schooner
Javelin ¶....	1879	55	51	8.6	4.6	2	C.I. 5 & 9 x 10	3.1	4.8	Patent coil	—
Julie ¶	1880	80	70	13	4.8	—	C.I. 11 & 8 x 10	—	—	One 5.5 x 6.5	Pole schooner
Leila **......	1878	100	92	15	6	—	C.I. 9 & 16 x 18	—	—	Patent coil 5⅜ feet diam.	**
Lookout ‖ ...	1876	105	96	16.3	5.2	5	—	—	—	—	—
Lurline ‖	1879	96.8	88.2	16.7	6	6.2	—	—	—	—	Schooner
Polynia ‡....	1880	157	146	18	10	9	C.I. 24 & 32 x 24	—	—	Two 10 x 11	3-m. pole schr.
Rhada §	1880	156	135	20.4	9.3	8.3	C.I. 26 & 26 & 26 x 24	7.5	12.5	One tubular 9.3 x 14	Schooner
Yosemite ‡..	1880	186	170	24	12	12	C.I. 40 & 40 & 28.5 x 33	11	17	Two cylindrical 12 x 11	**

* 4 Blades.

† Wood, sea-going. ‡ Iron, sea-going. § Composite, coasting. ‖ Wood, coasting. ¶ Wood, bay service. ** Composite, bay service.

N.B.—C.I. Compound inverted engines. The diameter and stroke are in inches.

The fore-mast of the Bretagne is 46 feet; main-mast, 48 feet; and mizzen-mast, 48 feet; top-masts, 37, 37, and 48 feet. Yards on fore and main, 60, 46, and 37 feet. Bowsprit (out board), 15 feet.

The Yosemite's masts are about 60 feet (deck to hounds), with top-masts of 30 feet.

The Corsair's masts are 60 feet, and 28 feet top-masts.

The Polynia's fore-mast is 46 feet above rail; main-mast, 50; and mizzen, 44 feet.

Area of Bretagne's sails is 25,000 square feet.

Area of Henriette's sails is the same.

The coal consumption of the Polynia at moderate speed is about eight tons per day; that of the Corsair about eleven tons; and of the Yosemite twelve tons.

Particulars of Some British Steam-Yachts.

Name.	Tonnage, Thames measurement.	Length, stem to stern-post.	Beam.	Depth.	Horse-power.	Engines.	Rig.	Built.	Character.
		FT.	FT.	FT.		IN.			
Wanderer.....	708	185.4	29.2	16.1	100	C.I. 25 & 50 × 30	3-mast. top-sail schr.	1878	Composite hull.†
Sunbeam......	532	159	27.6	13.9	70	C.I. 24 & 42 × 21	" "	1874	" "
Eothen......	340	152	22.2	12.2	70	C.I. 23 & 40 × 30	3-mast schooner	1864	Iron, sea-going.
Cecil..........	272	139	20.8	11.3	45	C.I. 21 & 36 × 21	3-mast. pole schooner	1872	" "
Cinderella	229	134	19.3	9.2	68	C.I. 17 & 34 × 20	2-mast. pole schooner	1874	" "
Elspeth........	174	130	17	9.3	45	C.I. 17 & 32 × 24	2-mast. pole schooner	1877	" "
Ina...........	126	103.2	16.5	7.6	40	C.I. 15 & 36 × 18	2-mast. pole schooner	1870	Wood, coasting.
Anthracite....	97	86.4	16.1	10	40	8, 16 & 23 × 15*	2-mast. pole schooner	1878	Iron, sea-going.
Gneta	86	95	14.1	7.9	40	C.I. 10 & 20 × 18	2-mast. pole schooner	1878	—
Gitana........	71	90	12.7	13.2	90	C.I. 3 cylinders	—	1876	Steel, cabin launch.‡
Firefly........	—	71.4	13.2	5.9	15	C.I. 9 & 18 × 9	2-mast. pole schooner	1877	Iron, coasting.
Miranda.......	54	45.5	6.5	—	70	S.I. 2 cylinders	—	1874	Steel, cabin launch.§
Glowworm....	21	50	10	5.5	10	S.I. 8 & 8 × 9	—	1878	Wood, harbor service
Gamecock....	12	48.1	7.6	3.8	8	S.I. 6 × 8	—	1875	Wood, cabin launch.
Sphinx........	5	33	6	3		S.I. 5 × 6	Lugger	1880	Wood, open.

* Perkins' patent.

† Auxiliary steam. ‡ Speed, 24 miles. § Speed, 20 miles.

NOTE.—C.I. means compound inverted engines. S.I. means simple inverted engines. The diameter and number of cylinders and stroke are given in inches.

STEAM-YACHTS.

No strict classification of steam-yachts has been made, one type blending into the other as we pass from river craft to those designed to navigate the open sea. The steam-cruiser is an elongated craft with the ends more or less fined away and the bilge rounded off; the river-yacht a light cockle-shell with flaring sides, a sharp entrance and clean run, her lack of depth being made good by superstructures of joiner-work; and the high-speed launch assumes the form of a lean-ribbed racer with knife-like entrance and attenuated after-body, the total displacement being made up of the weights of hull and driving-power.

The composite style of construction, iron-frames and wood-planking, has been successfully introduced wherever lightness and strength are of prime importance in the pursuit of high speed. Iron and steel hulls are also fast coming into favor.

SPARS.

MASTS are usually given one inch in diameter to every four feet of length, and booms and gaffs one inch to every five feet.*

In schooners the position of the masts vary, the object to be arrived at being the balancing of the centre of effort of the sails and the centre of lateral resistance. In round-bodied vessels with great flare to the bows, the former should be brought slightly forward of the latter, whereas in narrow, deep, long-bowed vessels, it may be placed directly over the centre of lateral resistance.

The rake of the masts of American yachts varies from one to eight to no rake at all. In English schooners the rake is about one to ten, and in their cutters the masts are stayed about plumb.

Top-masts are generally half the length of the mast, and fitted to house when not needed.

Fixed top-masts are used only in small river-craft.

Fixed bowsprits of small yachts are made of rectangular section, with the longest side placed transversely. They are objectionable in sea-going yachts unless very short, and are falling into disuse.

English yachts have running bowsprits which can be reefed or housed in bad weather, when a very small jib is carried. In American sloops the storm-jibs are hooked to an eye-bolt half way out on the bowsprit.

---

* The mizzen of a yawl with gaff-mizzen is about half the hounded length of main-mast.

(1) Fm. (2)
Spanker (5)

Examples of Spars of American Schooner Yachts.

Name.	Main mast, deck to hounds.	Fore-mast, deck to hounds.	Main top-mast.	Fore top-mast.	Main-boom.	Fore-boom.	Main-gaff.	Fore-gaff.	Bowsprit (outboard).	Jibboom.
America	71	62.6	25	24	58	Lug.	26	25	18	—
Caroline	38	37	18	18	40	15.8	18.6	15.8	15	7
Columbia	69.5	69.5	44	43	72.5	31	34.5	30	24.5	33
Crusader	56	54	35	34	58	24	27.6	23	35	—
Frolic	36	34	26	25	38	15	20	14	15	12
Intrepid	66.6	63.6	41.3	41.3	69	29	36.6	27.3	20	16
Mohawk	78.6	77	60	55	90	39	41.6	28	30	24
Norna	59	57	34	33	62	27	34	25	20	16
Republic	61	59	37	35	60	26	30	25	20	—
Sappho	73	68.6	52	50	81	35	47	33	30	36
Southern Cross	64	62	38	32	60	22	30	22	38	—
White Cap	58	56	20	20	56	20	28	19	18	—

Bowsprit and jibboom of Crusader, Southern Cross and White Cap, all in one stick.

Spars of American Sloop Yachts.

Name.	Mast, deck to hounds.	Boom.	Gaff.	Top-mast.	Bowsprit outboard.
Æolus	43	45	25	31	14
Arrow	64	63.1	33	28	32.1
Bloodhound	54	53	34	27	23
Corsair	43	44	23	24.6	23
Elephant	38	35	20.6	18.9	15
Fanita	48	47	26	23.6	20
Hesper (cutter)	41	46	26.6	31	25
Imperia	30*	44	23	22	20
Peri	35	38	19	22	22
Sunbeam	37	31.6	16	—	12
Wave	30*	42	28	28	20

* Signifies hoist of main-sail.

SAILS.

SAILS for large yachts are made of Nos. 6, 7, and 8 canvas, and for small craft of ten-ounce duck.

Storm-sails are made of Nos. 2 to 5 canvas.

Balloon-sails are made of light closely woven cotton.

Bolt-rope is of the best Riga hemp; the yarns well twisted, but the strands laid up only moderately taut.

ANCHORS AND CHAINS.

Length on water-line.	Number.	Weight in pounds of best bower.	Diameter of chain.	Weight per fathom.
25	2	50	3/16	3.5
35	2	75	1/4	5.5
45	2	130	5/16	6.25
60	3	200	3/8	9.5
80	3	400	1/2	17
100	3	500	9/16	21
120	4	700	11/16	30

For steam yachts deduct 25 per cent.

NEW YORK YACHT CLUB.

Sailing Regulations, &c., of the New York Yacht Club.

Rule I.—Classification.

Yachts shall be divided into classes as follows:

SCHOONERS INTO TWO CLASSES.

First Class to comprise those measuring 7,000 cubic feet and over.

Second Class to comprise those measuring less than 7,000 cubic feet.

SLOOPS INTO TWO CLASSES.

First Class to comprise those measuring 2,000 cubic feet and over.

Second Class to comprise those measuring less than 2,000 cubic feet.

Rule II.—Time Allowance.

Time shall be allowed for difference of measurement, according to the annexed table at the end of sailing regulations.

Rule III.—Notice of Measurement.

Owners of yachts requiring measurement shall give notice in writing to the measurer, specifying the time and place when and where their yachts may be measured—such time to be not less than twenty-four hours after the delivery of said notice, and such place some convenient part of New York harbor.

Upon said measurement, the measurer

shall receive such reasonable aid as he may require from the crew of the yacht measured.

Yachts having been once measured, need not be re-measured, except upon the written request of a yacht owner, or upon the direction of the Regatta Committee.

Any yacht-owner, however, may have the measurement of his yacht recalculated before any regatta, which new measurement shall be valid, provided it is certified to by the Chairman of the Regatta Committee.

Rule IV.—Ownership.

No member shall be interested in more than one yacht entered for a regatta.

Rule V.—Entry of Yachts.

No yacht can be entered for a regatta unless her ownership, rig, tonnage and dimensions, as computed by the measurer, in accordance with the rules of the Club, are on record with the Secretary.

Rule VI.—Entry of Yachts.

No entry for any regatta shall be received within forty-eight hours before the hour of starting; all entries to be made in writing, and delivered to the Secretary of the Club.

Rule VII.—Sails.

Yachts contending for prizes may carry sails as follows:

Schooners—Main-sail, fore-sail, fore stay-sail, jib, flying-jib, jib top-sail, fore and main gaff top-sail, fore and main top-mast stay-sail.

Sloops—Main-sail, fore stay-sail, jib, flying-jib, jib top-sail, and gaff top-sail.

Yachts may, however, set light sails over working sails at pleasure.

Rule VIII.—Models.

A true model of each yacht shall be deposited with the Secretary before she can be entered for any regatta.

Rule IX.—Boats.

Every yacht shall carry during a regatta a serviceable boat, as follows:

1st class schooners, a boat measuring not less than 16 feet in length.

2d class schooners, a boat measuring not less than 14 feet in length.

1st class sloops, a boat not measuring less than 12 feet in length.

2d class sloops, a boat not measuring less than 10 feet in length.

Rule X.—Number of Men.

Yachts contending for prizes shall not be limited in the number of men they may carry.

Rule XI.—Objections.

If any objection be made with regard to the classification or sailing of any yacht in a race, such objection must be made in writing to the Regatta Committee before three o'clock P. M. on the next day after the regatta.

Rule XII.—Station Boats.

A competent person may be placed by the Regatta Committee on board each station vessel to make observations.

Rule XIII.—Member in Each Yacht.

There shall be a member of the Club on board each yacht sailing for a prize.

Rule XIV.—Sounding.

Nothing but a hand lead and line to be used in sounding during a regatta.

Rule XV.—Touching Buoys, Etc.

A yacht touching any mark, boat, or buoy used to mark out the course, shall forfeit all claim to the prize, unless as in case specified in Rule XX.

Rule XVI.—Anchorage.

Yachts may anchor during a race without forfeiting their claim to a prize.

Rule XVII.—Floors and Bulkheads.

All yachts during a regatta to keep their floors down and bulkheads standing. Trimming by dead weight shall be allowed up to the time of starting, but not during the race; no ballast shall, however, be permitted to be taken in or discharged within twenty-four hours of the time named for any regatta.

Rule XVIII.—Courses.

Yachts on the port tack must invariably give way to those on the starboard tack; and in all cases where a doubt of the possibility of the yacht on the port tack weathering the one on the starboard tack shall exist, the yacht on the port tack shall give way; or if the other yacht keep her course and run into her, the owner of the yacht on the port tack not complying with this rule shall be compelled to pay all the damages that may occur, and forfeit his claim to the prize.

Rule XIX.—Courses.

Any yacht *bearing away* or altering her course to *leeward*, and thereby compelling another yacht to bear away to avoid a collision, shall forfeit all claim to the prize, and pay all damages that may ensue, unless when two yachts are approaching the windward-shore, a buoy or stake-boat, together with a free wind, and so close to each other that the weathermost cannot bear away clear of the leewardmost, and by standing further on would be in danger of running on shore, or touching a buoy or stake-boat, then such leewardmost yacht, on being requested to bear away, is immediately to comply, and will forfeit all claim to the prize for not doing so. The weathermost yacht must, however, bear away as soon as the one she hails, if she can do so without coming into contact.

Rule XX.—Rounding Buoys.

When *rounding a mark, boat* or *buoy*, the yacht nearest thereto is to be considered the headmost yacht; and should any other yacht in the race compel the yacht which is nearest to any mark, boat, or buoy, to touch said mark, boat, or buoy, the yacht so compelling her shall forfeit all claim to the prize; her owner shall pay for all damages that may occur; and the yacht so compelled to touch a mark, boat, or buoy, shall not suffer any penalty for such contact.

Rule XXI.—Courses.

Yachts going free must invariably give way for those by the wind on either tack.

Rule XXII.—Courses.

When two yachts (by the wind) are approaching the shore, a buoy or stake-boat together, and so close to each other that the leewardmost cannot tack clear of the weathermost, and by standing further on would be in danger of running on shore, or touching a buoy or stake-boat, such weathermost yacht, on being requested to put about, is immediately to comply, and will forfeit all claim to a prize for not doing so. The leewardmost yacht must, however, tack at the same time as the one she hails, if she can do so without coming into contact.

Rule XXIII.—Time of Performance.

In case the distance assigned for the race shall not have been performed in eight hours, the regatta to be repeated from day to day. If any yacht shall perform the distance in eight hours, the race shall be considered made, and the prize or prizes awarded.

Rule XXIV.—Ruling of Regatta Committee.

The Regatta Committee shall have full power to decide all questions that may arise in the sailing of the regatta, and also to exclude all yachts which by their decision have violated any rule of the Club.

There shall be no appeal from the decision of this Committee.

Rule XXV.

No prize shall be awarded in any class at any regatta in which less than two yachts start.

Rule XXVI.—Yachting Season.

The yachting season for all matches and races shall be limited to the period between the 1st of May and the 1st of December of each year.

Rule XXVII.—Amendments.

These sailing regulations may be amended at any meeting, but no amendment passed at any general or special meeting shall be valid until approved at a subsequent meeting, and any amendment must be submitted at one general meeting.

Rules of Measurement for Time Allowances of the New York Yacht Club.

The water-line of each yacht shall be divided into four equal parts, and a section taken at each point of division, making five sections. The area of each section from the rabbet-line of the keel to the line of the lowest point of the top of the plank sheer, as described in the rules, shall be measured and determined in square feet, and the cubical contents of the yacht shall then be got by the following formula taken from "Chapman's Rules for Measuring Vessels:"

To the sum of the areas of the first and last sections, add the sum of the areas of the even sections multiplied by four, and the areas of the odd sections multiplied by two. Multiply this sum by one-third of the distance between the sections, and add the cubical contents of the overhangs measured in each case, as shall, from the form of the boat, be most expedient, and the result thus obtained shall, for the purposes of this measurement, be deemed the cubical contents of the yacht.

To find the allowance to a yacht whose measurement comes between any two even hundreds in the table, deduct from the allowance to the even hundreds next below hers, such proportion of the difference between that allowance and the one next above it in the table as the excess of her measurement over the lower hundred bears to one hundred.

Table of Allowances

In Minutes and Decimals, by a Yacht Measuring Sixteen Thousan Cubic Feet, to Yachts of the Measurements Given Below.

Cubic feet.	Allowances.	Cubic feet.	Allowances.	Cubic feet.	Allowances.	Cubic feet.	Allowances.
15,900	.0275	11,900	2.0413	7,900	8.0018	3,900	25.6441
15,800	.0558	11,800	2.1249	7,800	8.2493	3,800	26.3768
15,700	.0848	11,700	2.2108	7,700	8.5037	3,700	27.1297
15,600	.1146	11,600	2.2991	7,600	8.7650	3,600	27.9033
15,500	.1453	11,500	2.3899	7,500	9.0330	3,500	28.6981
15,400	.1768	11,400	2.4831	7,400	9.3095	3,400	29.5148
15,300	.2091	11,300	2.5789	7,300	9.5930	3,300	30.3540
15,200	.2424	11,200	2.6773	7,200	9.8843	3,200	31.2162
15,100	.2765	11,100	2.7784	7,100	10.1836	3,100	32.1022
15,000	.3117	11,000	2.8823	7,000	10.4912	3,000	33.0125
14,900	.3477	10,900	2.9891	6,900	10.8072	2,900	33.9478
14,800	.3848	10,800	3.0988	6,800	11.1319	2,800	34.9089
14,700	.4229	10,700	3.2115	6,700	11.4655	2,700	35.8964
14,600	.4620	10,600	3.3273	6,600	11.8083	2,600	36.9110
14,500	.5022	10,500	3.4463	6,500	12.1605	2,500	37.9536
14,400	.5435	10,400	3.5686	6,400	12.5225	2,400	39.0248
14,300	.5860	10,300	3.6942	6,300	12.8943	2,300	40.1255
14,200	.6296	10,200	3.8233	6,200	13.2764	2,200	41.2564
14,100	.6744	10,100	3.9560	6,100	13.6690	2,100	42.4185
14,000	.7204	10,000	4.0923	6,000	14.0724	2,000	43.6125
13,900	.7677	9,900	4.2323	5,900	14.4869	1,900	44.8393
13,800	.8164	9,800	4.3762	5,800	14.9128	1,800	46.0999
13,700	.8663	9,700	4.5240	5,700	15.3504	1,700	47.3951
13,600	.9176	9,600	4.6759	5,600	15.8000	1,600	48.7260
13,500	.9704	9,500	4.8320	5,500	16.2620	1,500	50.0935
13,400	1.0245	9,400	4.9924	5,400	16.7368	1,400	51.4985
13,300	1.0802	9,300	5.1572	5,300	17.2245	1,300	52.9423
13,200	1.1374	9,200	5.3265	5,200	17.7257	1,200	54.4257
13,100	1.1962	9,100	5.5005	5,100	18.2406	1,100	55.9499
13,000	1.2566	9,000	5.6793	5,000	18.7698	1,000	57.5160
12,900	1.3187	8,900	5.8629	4,900	19.3134	900	59.1252
12,800	1.3824	8,800	6.0517	4,800	19.8720	800	60.7786
12,700	1.4479	8,700	6.2456	4,700	20.4460	700	62.4775
12,600	1.5153	8,600	6.4448	4,600	21.0358	600	64.2232
12,500	1.5844	8,500	6.6496	4,500	21.6418	500	66.0168
12,400	1.6555	8,400	6.8599	4,400	22.2644	400	67.8598
12,300	1.7285	8,300	7.0761	4,300	22.9042	300	69.7534
12,200	1.8036	8,200	7.2982	4,200	23.5616	200	71.6991
12,100	1.8807	8,100	7.5264	4,100	24.2370	100	73.6984
12,000	1.9599	8,000	7.7609	4,000	24.9310		

Extracts from the By-Laws of the New York Yacht Club.

PENDANTS.

The commodore, when afloat, will wear a broad pendant, with a foul anchor encircled by thirteen five-pointed stars in white, on a blue field; the vice-commodore shall wear a broad pendant, with a similar device on a red field; and the rear-commodore will wear a broad pendant, with a similar device, in red on a white field. The acting commodore will wear a broad pendant, blue field, without device.

HOISTING COLORS.

All yachts, when in service, shall hoist their signal-flag and ensign at eight o'clock A.M. of each date from the 21st day of March to the 21st day of September, and at nine o'clock A.M. from the 21st day of September to the 21st day of March, and haul them down at sunset. When sailing, the ensign may or may not be set, at the option of the captain.

When two or more yachts are sailing in company, or are at anchor within sight of each other, they will take the time for hoisting their colors in the morning, and hauling them down at sunset, from the senior officer in command.

No guns to be fired on setting or hauling down the colors, except by the yacht giving the time.

SALUTING.

Every yacht passing another of the Club shall salute by dipping the ensign or by firing a gun, juniors in rank saluting first.

COURSES.

There shall be two courses for regattas, an inside and an outside course, as follows:

Inside Course.—Start from an imaginary line between the Club House at Staten Island, and a stake-boat anchored abreast of it, thence to and around buoy No. 10, near S.W. Spit, passing to the W. and S. of it, thence S. of buoy No. 8½, and N. of buoy No. 5, off the point of Sandy Hook, to and around Sandy Hook light-ship, turning it from the N. and E., and returning over the same course to the westward of the home stake boat, which shall be anchored abreast of and to the eastward of buoy No. 15.

All yachts must pass to the eastward of West Bank buoys Nos. 11, 13, and 15, both going and returning.

Outside Course.—Start from an imaginary line between buoy No. 10, near S.W. Spit, and a stake-boat anchored S. of it, thence S. of buoy No. 8½ and N. of buoy No. 5, off the point of Sandy Hook, to and around Sandy Hook light-ship, turning it from the N. and E., thence to and around a spar-buoy with red and black horizontal stripes, turning it from the W. and S. to and around Sandy Hook light-ship, turning it from the S. and E., thence to the starting-point, passing buoys Nos. 5 and 8½ as before.

The red and black spar-buoy above mentioned is moored about one and one-half miles off the land, and bears S.S.E. from Highland Lights, distant four miles.

REGATTA.

There shall be an annual regatta in the month of June, over the inside course.
At the first general meeting in each year, the time of said regatta shall be determined. An appropriation shall be made at the same time for defraying the cost of prizes for the regatta, and all other expenses appertaining thereto, which appropriation shall not be exceeded without the written consent of a majority of the officers of the club.

SELECTING A YACHT.

IT is recommended to the amateur about commencing a yachting career to buy, in preference to building, a yacht. It is also preferable to begin with a small yacht in order to be able to judge, at small expense, whether the sea and its pastimes suit in both a physical and a pecuniary point of view.

Before buying, have the craft laid up on shore or in a dock, where you can examine her hull. Examine the copper along the water-line, as there the first decay is usually found, owing to the alternate action of wind and water; examine minutely the stern-post, the rudder-post, and rudder-fastenings. Should there be any red weeps in any part of the copper, they denote iron-fastenings in the bottom planking which will speedily give way. If she has been on shore and bumped on a reef or hard sand, her false keel will show it by being torn and jagged, or else by new pieces let in, and if she has damaged frame-work, her copper will exhibit a series of wrinkles in the immediate locality of the injury. Sometimes faint wrinkles will originate from the frame of the vessel working while she has been hard carried on; such a vessel must be carefully examined. Note well any straining that appears in the wake of the chain-plates; see that the top side is well calked, as well as just where the copper joins the bends.

Now go on board, and have enough of the ballast removed to get at the floor timbers; have a chisel or strong knife to test the floor timbers in various places for dry or wet rot; have a good look at the breasthook forward.

Examine well the top timbers through which the bolts of the chain-plates are driven, also all the top timbers along each side.

The stringers which are bolted along the top timbers fore and aft the vessel on both sides should be strictly examined, as they are very likely to become *decayed.*

Examine all the deck beams, the mast beams particularly; any straining that shows in these or the bulkheads betrays a hard spent life and a weakly constitution.

See that the mast is stepped in a proper step, and that the spar is not *tongued* below the deck, of which the presence of iron bands upon it will apprise you.

While below, see that the pumps and private closet work well, that the former have box-valves, and that the supply-pipe of the latter cannot accidentally be left open.

Next ascend on deck and examine the bulwark stanchions along the covering board, to see that they are sound; the water-ways and seams of the deck, to see that they are properly calked and payed; take note that the sky-lights are tight, and that they have grooved channels in the frames to carry any leakage off on deck.

Be careful that the counter-timbers are sound where they join the deck; while examining the deck-fittings, carefully overhaul the windlass, and see that it works properly; also that the hawse-hole is in the right place, so that the chain leads fair to the windlass.

Next proceed to examine the spars, to see if they are sprung. Look carefully to the masts above the deck, above and under the saddle, and just below where the gaff works; if the mast is badly sprung at the hounds it will rake aft considerably with the weight of the main sail, so get the weight of the latter upon it by means of the halliards, and it will tell its own tale. Look for rot about the eyes of the rigging, where the mast is often soft and spongy in the nip of the rope.

The top-mast, if sprung, will generally show it just above the lower cap; the bowsprit just outside the gammoning; and the boom in the slings, or a few feet from the "goose-neck."

Look well to the "goose-neck," and all blocks and sheaves; back out the pins and examine the sheaves of several. Observe closely the main-sheet blocks; look well to the bowsprit gear-blocks, and the dead-eyes of the main rigging; see that the top-mast fids, unfids, and houses with perfect freedom. Proceed now to the standing and running-rigging.

Wire has now in a great measure superseded rope for standing-*rigging.*

Of the running-rigging, look out particularly for the top-mast and

bowsprit-rigging, the main and peak-halliards, main-sheet, fore and jib-halliards, runners and tackles, and jib and fore-sheets.

Sails.—Examine well the suit of canvas for indications of mildew. Have them spread on a level surface, so as to easily see any patches or butts, and if, upon holding the canvas up between you and the light it looks streaky, reject it at once.

Examine the luff-ropes and tacks of all sails, and if they appear much stretched, and the tabling, or strengthening pieces rent, they have had hard usage, and are more or less out of shape.

New Sails must be stretched. To stretch a main-sail, lace the head of the main-sail along the gaff, hauling the head-earing hand-taut only, then lash the clew *well out* toward the boom end; pass a mast-lacing, and hoist the sail; gradually tauten the mast-lacing until you get the sail perfectly flat. Lace the sail to the boom, and let it flap about all day in fine weather, repeating the proceeding for a week; then come up the clew-lashing, seize the mast-hoops on; get the head of the sail well out on the gaff; get the main-tack down, and haul out the boom-earing tautly; let the sail knock about for another week, each day taking a fresh pull at the head-earing, clew-lashing, and main-tack, so that the sail may become evenly stretched in every direction.

The time occupied will be well spent, and your main-sail will be in a condition to take the speed properly out of your yacht.

Gaff top-sails are to be stretched by lacing them hand-taut to the yards at first, and gradually increasing the stretch, getting the tack down gently and the sheet home an inch or so every day. Hoist the jib and fore-sail without sheets, and let them flap about. Never stretch sails in wet weather. Never reef a new sail until it has been well stretched, or you may ruin it.

YACHTS' BOATS.

A VERY important department of your fit-out for the season is that of your boats; not only in their selection in the first instance, but the manner in which they are kept, the proper description of oars, fenders, etc.

In the selection or building of your boats, be particular to combine lightness with strength, buoyancy with stability, and speed with seaworthiness.

By attending to these points minutely you will become possessed of boats having the most perfect qualifications for all purposes of cruising or racing; firstly, they will be found easy to get on board, not unnecessarily cumbrous on a vessel's deck, and bear knocking about and beaching without becoming leaky, than which nothing can be more wretchedly uncomfortable; secondly, they will tow lightly, carry sail or considerable weight without danger of capsizing, will be found admirably convenient in landing on shoal-beaches, and should you have to leave your gig over your slipped anchor and chain during a race, and it comes on to blow, with a strong tide, she will escape the chance of foundering; thirdly, they will be able to take you off against a head wind and sea smartly, keeping their crew, passengers, and luggage dry, and should you require to tow your vessel in a calm, will assist the exertions of the crew materially.

To secure speed with seaworthiness, length is a great object, and having regard to the capacity of your yacht for stowing them on deck, you should give the boats the utmost inch you can in length, proportionate to their beam.

The entrance should be as fine as a knife below the water-line, and the delivery tapering moderately fine aft, but gradually, so as not to leave a lump under the quarter; over the water-line forward let the bows flare out well—they will prove a good lifting power in a heavy sea, will dash the water aside instead of taking it in, and by enabling the beam to be carried throughout aloft, will give more room on the thwarts for the men, and consequently more power over their oars.

The upper lines aft should gradually swell outward also, up to the benches for the sitters, and be rounded neatly to the transom. Thus you will secure a good roomy boat, with her floor carried well fore and aft, having a fine bottom with the least displacement, and good stability in her body.

Another very particular point in the fitting of yachts' boats is the placing of the thwarts, row-locks, and stretchers, so as to enable the rowers to exercise their muscular powers with the most beneficial effect; if the thwarts are placed too high or too low, the row-locks too near or too far, and the stretcher not so as to give a good purchase to the feet, the best man that ever handled an oar will be placed at serious disadvantage, and the crew cannot row with such

strength and in such form as will be useful or creditable. The thwarts should be placed so as to enable the men to sit well over their oars; the row-locks so that they can reach well forward to grasp the water ahead with their oars; and the stretcher so that the whole power of the stroke may be given from the legs; by having these details properly looked after, the crew will be enabled to exercise their powers in propelling the boat to the best advantage, and with the least bodily distress to themselves.

Of whatever wood the oars are made, see that the strength of the loom is carried well down to the blade, and that the latter be not too long or too wide; wide blades to oars do not propel a boat a bit faster than moderate-sized ones, and rowing against wind they are killing on men, besides being clumsy and liable to be smashed. A neat, well-shaped blade will enable a man to row clean, fast, and strong, and to stick to his work besides. The blades of all oars and paddles should be neatly banded with copper close to the ends, to prevent them splitting.

A spare oar or paddle should always be carried in case of accident; two boat-hooks should be in the gig, and one in the dingy.

A neat brass-yoke, with cotton-lines for the rudder; a handy water-breaker; a galvanized grapnel, with good length of painter; mast and lug-sail; and a boat compass, complete the equipment of your gig.

It has been found of advantage to the steering of a boat to have the rudder made deeper than usual, so as to project below the keel. In such a case, it is necessary that the rudder-pintle must be made double the usual length, or quite as much longer as the rudder descends below the keel. A pennant of light line is rove through an eye in the rudder, and let through a score in the transom into the stern-sheets, so that when you are getting into shoal water, by hauling on the pennant you can lift the rudder on a level with the keel, to prevent it striking the ground and being carried away. The bottom of the rudder should be rounded to prevent its catching weeds, grass, etc.

Dark crimson, blue, or green leather cushions, and a handsome mahogany backboard, with the name of the yacht or the armorial bearings of her owners emblazoned thereon, add a finished and elegant appearance to the stern-sheets of a gig.

And now a few words *as to* the handling of your gig, for, simply

it may appear, there is some little skill required to do so properly. First, then, when the gig is ordered alongside, let her be brought up so that the stern-sheets shall be immediately opposite the accommodation-ladder; the stroke, first and second beam oarsmen will be seated with their oars tossed, the handle resting on the floor, the bowman standing, holding on forward with his boat-hook; the boat's mast with the lug-sail nearly furled, the spare oar, and the stroke oarsman's boat-hook laid amidships along the thwarts. Cast your eye over the boat, and see that she is spick and span, clean as a new pin; that the crew are attired alike in the proper uniform, suitable to the weather, with the vessel's name on their hat-ribbons. If you are going a distance from the yacht, see that their oil-skins are stored away for use, in case of a change of weather; that the water-breaker is full and in its place; a large sponge; a mop; a boat-scoop or baler; and the grapnel, ready for service, should you have to land on a beach. Having satisfied yourself that all is correct, your sailing-master, in his uniform, will stand by to hand you and your friends the man-ropes. Your steward will look after your hard-weather tackle; the stroke oarsman will turn back the cushion next the ladder to prevent it being soiled by foot-marks until all the sitters are in. Seat yourself at the yoke-lines, and give the order "Shove off." Your bowman, with a vigorous shove, will send the boat's head away from the yacht's side, then lay his boat-hook in amidships, and toss his oar the same as the others. You then give the word "Let fall;" the four oars are dropped simultaneously and lightly into the water, and, with a good, steady stroke, the boat is under way.

With respect to the rowing, you must work your crew into a good style. Let each man sit square upon his thwart, and rather on its after edge, looking neither to port or starboard, but right aft. Let the stretcher be rather short for his legs than otherwise, his heels touching and his toes turned well out; let the back be held straight, the head erect, and the chest thrown out, the arms loose and free, the outer hand near the end of the oar, and the inner one just on the swell of the loom, for the purpose of feathering. Then let every man throw his body aft simultaneously with the stroke-oarsman, and shoot out his arms at the same time over his toes, straight and low, which will enable him to feather high, and row clean in a heavy sea. *Chop the oar* into the water until the blade is covered, and no

deeper, heave his body back with an uniform, easy, yet powerful swing, keeping his arms straight until just the end of the stroke, when he should bring his elbows back close to his hips until his hands lightly touch his body below the ribs. The swing back and the power of the arms are greatly assisted by straightening the legs; and, in fact, a good oarsman uses his legs as much, if not more, than his arms in giving effect to the stroke.

The moment the oars grasp the water well forward, they should be ripped through it with a swing, and the body should not be thrown far back, as it is an expenditure of force without corresponding results. Once the oar-blade passes a little beyond the row-lock, it should be delivered, and if the spray is dashed aft, and not upward, it shows that each man is rowing his stroke fairly through the water.

If you are going to a landing stairs, or alongside of another yacht, you must use your yoke-lines with a little judgment. Keep somewhat to leeward of the object you want to get alongside of; bring the boat's head round with an easy sweep, at full speed; as you near it give the order, "In bow." The bow-oarsman will then lay in his oar and stand in the bow, boat-hook in hand. When you have judged the distance that she will run up with her way alone, give the order, "Oars;" the other three men will toss up their oars and lay them in with the blades forward, taking care as they do so not to let all fall with a crash on the head or body of the bow-man; then, as she closes in, give her head another sheer out, and she will glide alongside handsomely, when the stroke-oarsman, with his boat-hook, assists the bowman to hook on. The fenders are thrown over the gunwale by the other hands, to prevent her sides being chafed, and when you get on shore, or on board another vessel, she is shoved off to the extent of the boat-hook staffs, or, should other boats be coming alongside, lies off under a pair of oars until required.

Should you ever find yourself in danger of running into another boat that may appear suddenly from behind a vessel in a crowded harbor, the simple order, "Stern all," to the crew will bring your boat up all standing by their instantly holding water with the oars and backing strongly.

Should you be caught in a heavy broken sea whilst making for the yacht, and you find it overpowering you, get the boat's head to it and lie on the oars, just keeping steerage way until she bears down

to you. Whilst waiting her approach, if a very heavy comber come rolling down upon you, keep her stem on to it, and, as it comes near, back her steadily before it, so as not to offer any resistance; she will rise at the same time that she recedes from it, and the moment it rolls under her, make the crew give way a stroke or two steadily; give her a sheer, with the rudder transversely across the back of the wave, so as to prevent her pitching too heavily to recover herself before the next comes on; meet her again with the helm, and enter her fairly to the sea as before, backing her from its violence, and thus you will make excellent weather of it until the yacht arrives to your assistance. It requires just a little coolness, a quick eye, and a ready hand; your crew perceiving you are possessed of these qualifications will have perfect confidence in you. When the vessel nears you, she should run up under your lee, so as not to give you her wash in addition to the weight of the sea, and heave-to to windward; you can then pull up under her lee, humoring the seas as before; let her crew heave you a line, which pass under the foremost thwart, and sheer the boat off clear of her, veering and hauling on the line as the sea may require. The moment a smooth time offers, make a dash for the main-rigging; don't attempt to board her on the lee quarter, for should she make a sudden 'scend in the sea she would smash you, boat and crew, into very respectable fragments under her quarter with her main-boom. Get the oars, cushions, etc., out of her; unship the rudder and thole-pins; make fast the end of another painter along with her own to the ring-bolt in her stem, and, veering out a good scope of both, make them fast on each quarter of the yacht; thus you will tow her steadily until opportunity offers to take her on board.

In boarding a yacht under way with a punt or dingy, in moderate weather, the moment you heave the painter to the men on deck jump aft and sit down, when they can haul you alongside safely; but if you remain forward, from the bow being deeper than the stern through your weight, she will take a sheer and turn bottom up with you to a certainty. If the crew should heave you a line, do not attempt to hold on to it with the idea of hauling yourself alongside; if you do, she will take a sheer from the same cause, and over she goes; let them veer it out until you have made it fast forward *and gone aft*, and then they can haul up.

No yacht should be without a couple of life-buoys, one on each

quarter, looped up with beckets and toggles, and always ready for immediate use. Bosses and seats made of painted canvas, stuffed with cork shavings, and having becket-loops round them, are extremely convenient on board a yacht, and make excellent life-buoys. With air-tight copper or zinc vessels fitted into the bow and under the stern-sheets of your gig, and with vulcanized India-rubber tubing placed under the thwarts, you can convert her into a very respectable life-boat, and although she will not possess all self-righting and other qualities, yet still, though filled with water, she cannot sink under you, and even moderate assistance will keep a number of men floating until succor reaches them.

"The International Code" being the one generally adopted by yachtsmen, and recognized, is that best adapted for you to make yourself acquainted with. As this code enters fully into all details of day and night signalling, it would be superfluous my doing so, furthermore than telling you that to work day signals properly and sharply, you must have two complete sets of flags; irrespective of the purposes for which you require them, they will give your ship a very imposing appearance when she is "dressed in her best" for regatta days or other state occasions.

The best plan for keeping these flags in order, and ready at any time for use, is to have two rolls of canvas made somewhat similar in shape to a portable dressing-case; let each roll be sewn with rows of pockets, having the number or name of each flag legibly printed thereon; thus the two sets will be kept distinct, confusion avoided, and you can turn from one roll to the other for the flag you require, while those that have been used are being folded and returned to their respective pockets for further use.

The moment you discover a signal made, write down the number of the flags the first thing; then refer to your code and ascertain its reading, writing it opposite the numbers you have taken down; seek for an answer suitable, write it down, below the question, with the numbers of the flags that make it opposite; then proceed to answer the question by hoisting these flags.

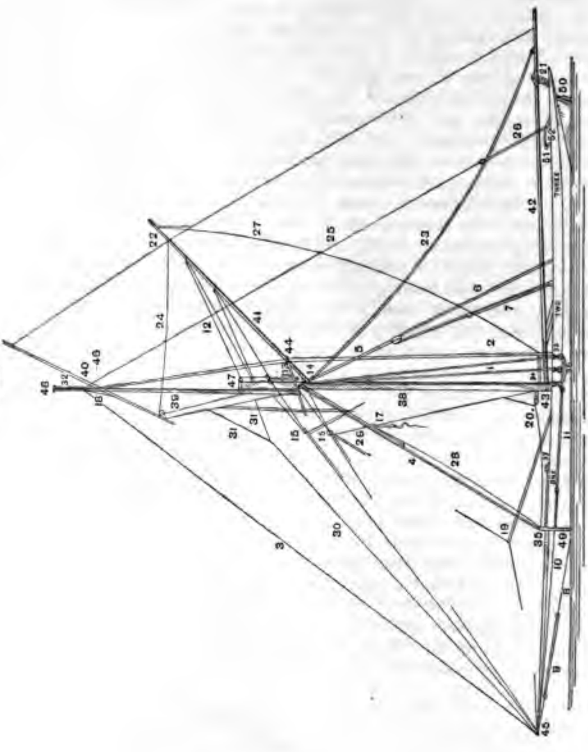


Plate I.

RIGGING AND SAILS.

INTRODUCTORY NOTE.—For convenience of description, it has been found necessary to select some particular rig, and the cutter has been taken, because it has peculiar features, and is coming rapidly into favor for yachts intended for use in open water.

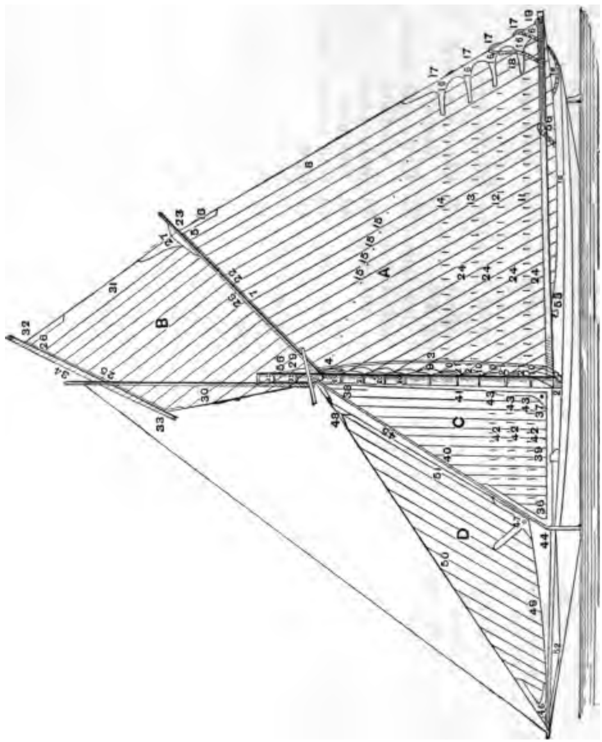
The author is aware that there is great difference of opinion among yachtsmen concerning the best manner of performing many evolutions, and has endeavored to select those which have stood the test of time, and are now in general use among cutter-sailors.

PLATE I.—STANDING AND RUNNING RIGGING, SPARS, ETC.

1. Main shrouds.
2. Top-mast shrouds.
3. Top-mast stay.
4. Fore-stay.
5. Runner-pennants.
6. Runners.
7. Runner-tackles.
8. Bobstay.
9. Bobstay-tackle.
10. Bowsprit-shrouds.
11. Bowspritshroud-tackle.
12. Peak-halliards.
13. Mainorthroat-halliards.
14. Eyes of the rigging.
15. Balloon-jib halliard.
16. Working-jib halliard.
17. Fore-halliards.
18. Gaff top-sail halliards.
19. Jib-sheets.
20. Fore-sheets.
21. Main-sheets.
22. Gaff top-sail sheet.
23. Boom topping-lifts.
24. Gaff top-sail clew-line.
25. Top-mast back-stay—used when running off a wind.
26. Top-mast back-stay tackle.
27. Peak-downhauland ensign-halliards.
28. Fore-downhaul.
29. Jib-downhaul.
30. Gaff top-sail bow-line.
31. Gaff top-sail bow-line bridle.
32. Signal-halliards.
33. Dead-eyes and shroud-lanyards.
34. Sheer pole.
35. Bowsprit gammon-iron.
36. Channels and chain-plates.
37. Bowsprit-bitts and windlass.
38. Main-mast.
39. Top-mast.
40. Gaff top-sail yard.
41. Gaff.
42. Boom.
43. Saddle of boom with spider-hoop.
44. Cross-trees.
45. Jib-traveller.
46. Gaff top-sail tye-traveller.
47. Mast-head cap.
48. Truck.
49. Stem—cut-water.
50. Stern-post and rudder.
51. Tiller.
52. Quarter timber-heads.

One, Port bow.—*Two*, Port beam.—*Three*, Port quarter. And for the starboard side of the vessel, starboard bow, beam, and quarter.

Plate II.



MAIN-SAIL.—A.

1. Main-tack.
2. Main-tack tackle.
3. Main-tack tricing-line.
4. Nock or throat.
5. Peak.
6. Clew.
7. Head.
8. Leech.
9. Luff.
10. Foot.
11. First reef.
12. Second reef.
13. Third reef.
14. Close reef.
15. Balance reef — seldom used in yachts.
16. Strengthening pieces.
17. First, second, third, and close reef-cringles.
13. First and second reef-pennants rove.
19. Main-clew lashing, or traveller on the boom.
20. Mast-hoops and seizing.
21. Luff-cringles.
22. Gaff-lacing.
23. Peak-earing.
24. Reef-knittles or points.

GAFF TOP-SAIL.—B.

25. Head.
26. Peak.
27. Clew.
28. Foot.
29. Tack.
30. Luff.
31. Leech.
32. Peak-earing.
33. Head-earing.
34. Yard-lacing.
35. Mast-head lacing.

FORE-SAIL.—C.

36. Fore-tack.
37. Clew.
38. Head.
39. Foot.
40. Luff.
41. Leech.
42. Reef-knittles or points.
43. Reef-cringles.
44. Fore-tack tackle rove through a sheave in stem-head.
45. Fore-sail lacing, or hanks, or horn thimbles.

JIB.—D.

46. Tack hooked on to the traveller.
47. Clew.
48. Head.
49. Foot.
50. Luff.
51. Leech.
52. Inhaul of the traveller.

SUNDRIES.

53. Reef-tackle cleat and eye-bolt.
54. Tumbler to the jaws of gaff.
55. Mast-rope of the top-mast.
56. Reef-earing bee-blocks.

HANDLING A CUTTER YACHT.

Preparations for Getting Under Way.—Take off the sail covers. Loose the main-sail; hook the main and peak-halliards; man the topping-lifts and top up the boom, one hand overhauling the main-sheet to allow the boom to rise.

Man the main and peak-halliards and hoist away, observing that the ensign-halliards are clear; with double topping-lifts enter the gaff between them as the sail goes up. Get the throat well up first, and then sweat up the peak; belay the halliards, and finish the setting by the purchase.

Set up the runners and tackles; haul taut and belay the main-sheet, coil down the slack of it and capsize the coil clear for running. Clear away the deck aft of all spare gear.

If the gaff top-sail is to be set, send it aloft after the main-sail is set, and before touching the head-canvas.

If only one top-sail sheet is fitted, be careful to send up the sail on the proper side of the gaff. Bend on the halliards about one-third the length of the yard from the fore end, and the sheet to the clew of the sail, observing to have both clear of the topping-lifts.

Lash a small tail-block on the fore-end of the yard, through which reeve a light clew-line, making the standing part fast to the clew of the sail, and having the fall lead on deck. Hook a tack-tackle on to the tack and sway aloft, keeping the sheet clear of the gaff as it goes up. When chock up, belay the halliard and get the tack down by the tackle; if there is a lacing, have it passed round the top-mast and mast-head; round in the top-mast stay till the top-mast has a slight rake forward, and then sheet home the top-sail.

Thus, having set the after-canvas, proceed to clear the ground tackle.

If riding to single anchor, heave short, and as the cable comes in have a hand at the stem-head to cleanse it before it enters the hawse-hole.

If riding to moorings, cast the bridle off the bitts, take a turn there with the buoy-rope, and, passing it under the bowsprit-shrouds and head-sheets, stream it and hang on by the bight of the buoy-rope.

Slack the top-mast stay and get the bobstay well down, then ease the top-sail sheet and get the top-mast forward again, after which *sheet home* the sail.

See the bowsprit-shrouds well taut.

Next reeve the fore and jib-sheets, get up the fore-sail and lace it to the fore-stay; or, if it works on hanks, see it clear; hook on the sheets and halliards, and leave it handy for running up, taking care to belay the fore-sheet on the side opposite to that on which you intend to cast the vessel's head, but slack enough to permit the sail to hoist freely.

Now get the jib along and bend on the sheet, observing to have an overhand knot on the ends of the sheets to prevent their being unrove by the flapping of the sail while hoisting; hook the jib to the traveller on the bowsprit, then hook on the halliards, seeing them clear of turns and of the stay. Man the jib-tye fall and run the sail out until the clew clears the fore-stay. Hoist on the halliards to keep the sail out of the water, and run the traveller out to its berth; then belay the tye-fall to the bitts, run the jib up taut with the purchase, and overhaul the purchase well in order to get the full length and power of the tackle during the day's cruise.

If you are not going to get under way immediately, instead of hoisting the jib it may be stopped on the bowsprit, just outside the stem, with a single gasket; or a neat and handy way is to have a small block aloft, alongside the fore-halliard block, with a light whip rove, having a thimble and hook at the end; then when the jib is out and set, hook on the whip to the jib-clew, and clew up the foot of the sail along its luff, which keeps the sail handy and out of the way of flapping about.

You are now all ready, and the last care will be your boat. If you intend towing her astern, be sure that the painter is stout and well-belayed inboard; should it come on to blow fresh, with a heavy sea, give her a good scope of painter, especially if you are running before the wind. If, however, the wind should be light, you may shorten her up close astern, as she will tow so much easier.

Slipping from regular moorings, it is a good plan to hold on to the buoy, when you get way on, until you stream it out into a clear position for coming-to again.

Being "All ready," ship your tiller, ease away the main-sheet sufficiently, trim the jib-sheet, run up the fore-sail, cast off the buoy-rope, and, as her head pays off, trim the main-sheet.

See the fore and main-tacks well down. Keep her a good clean "full-and-bye."

CRUISING.

BE careful, no matter how fine the weather is, to have the down-hauls always bent, and halliards clear for running. At least one reef-earing should be rove, and in reeving pass it up through the score in the boom-blocks, thence through the cringle on the main-sail, and down under the sheave in the block on the other side of the boom. The fall may be taken inboard and made fast to the boom; or, if the day looks threatening, the reef-tackle may be hooked at once to the boom, and the earing bent to its hook with a Blackwall-hitch. The tackle should then be overhauled along the boom, and made fast with two or three turns of its own fall round both boom and tackle.

A main-tack tricing-line should be a gun-tackle purchase, having a tail to the lower block; when bent to the tack-thimble the tail will hang free, and by hitching it round the boom a down-haul may be made instantly for the throat of the main-sail.

Have a look all round, immediately after you get fairly under way, and take heed that the main and peak-halliards, head-halliards and main-sheet, are all coiled down and the coils capized clear for running.

You are now fairly under way, sailing on a bow line, with every sail telling, and a moderate sea on. The tiller is pressing against your hand with a tremulous vibration. You are going along nicely, with a fresh breeze—we will suppose on the port tack—and desire to go about.

Tacking.—When ready, sing out "Ready about." See that a hand goes to the jib-sheets, another to the fore-sheets, and one to the main-sheet. When all are at their stations, the man at the jib sings out "All ready, sir." Then put your helm gently over to lee-ward, calling out at the same time, "Helm's a-lee." Let her shoot well a-head in stays, helping her on by hauling in the slack of the main-sheet, which will keep her main-sail full and telling to the last moment.

Mind that your jib-sheet man does not let go the sheet by the run. It should be eased up handsomely and steadily until she is fairly *head to wind*. and the lee sheet should not be hauled until she is fairly *in the wind* and just paying off, otherwise the sail will get aback,

and prevent her coming round quickly; then, the moment the sheet flutters to the lee of the stay, the sheet should be hauled home like lightning, and securely belayed; the fore-sheet should be eased off directly she pays away—never keep it to windward a moment unless you are in a heavy seaway; both sheets should go over almost together. A vessel must be very much out of trim if she requires to be boxed off with the fore-sail aback. Shift the main-tack tackle to windward of the boom, and bowse the tack down; if two tack-tackles are used, come up the lee-tackle and haul taut the weather one.

Vessels are sometimes kept away at first, in order to get more way on, and this should be done very carefully, as, if kept away too much, she sweeps round in a great circle when the helm is put a-lee, and the moment the sheets are eased up she loses headway, probably misses stays, or has to be boxed off by hauling the head-sails to windward.

Let the fore-sheet man be particular to let go and overhaul what will then be the weather topping-lift, so that it may not girt the sail. If not done in time, the pressure of the sail and gaff will prevent the lift from rendering through its block. Also, when the same hand belays the lee-sheet, he should step to windward and haul taut the other topping-lift. Should the gaff top-sail not be standing well, it should be trimmed while in stays.

When fairly on the other tack, see that the jib and fore-sheets are trimmed so that the sails are a good clean full, and that the head-sails are standing at the same angle as the main-sail. An inch or two of the head-sheets, one way or the other, may have great effect on the speed of the vessel; if too flat aft, she is bound and her way deadened; if too slack, they are not doing their work, and the vessel is propelled by the main-sail alone.

PREPARATIONS FOR HEAVY WEATHER.

Shortening Sail, etc.—On the first indication of the approach of a gale, send a hand aloft to cast off the lacing of the top-sail, man the halliards, tack and clew-line, and tend the sheet; ease away the sheet handsomely, clewing up the sail at the same time; ease away the halliards, hauling down on the tack and clew-line, and keeping the sail clear of *the eyes of the* rigging as it comes down. If the

standing part of the clew-line is made fast to the fore end of the yard, it will facilitate getting the sail down clear. Unbend the gear, make the sail up on the yard and lay it along the deck ready to set again if required. Get up the small jib and lay it along tack forward and head aft, clear of the weather fore-sheet.

Ease away the lee, and haul in the weather fore-sheet, luff the vessel up in the wind, haul in the main-sheet, cast off the tack tackle, and trice up the tack.

The vessel is now "hove to," and you may shift the jibs. Let go the traveller, and the jib will fly in; let a hand muzzle it in the lee of the fore-sail. Let go the halliards, unbend the sheets, and pass them across outside the fore-stay to be bent to the other jib; unhook the tack and halliards, which latter pass to windward; then hook the fresh jib on the traveller next the halliards; run the jib out and set it, allowing the lee-sheet to remain flowing.

Reefing.—Now ease up the main-sheet, man the topping-lifts and get the boom well up, then haul in the main-sheet again; ease the main and peak-halliards the depth of a reef; get the reef-tackle clear, and the reef-earing well down and stoppered, unhook the tackle, and pass a couple of turns of the earing round the boom, forward of the standing part, and make fast. Tie the reef-points, hoist away the halliards, and set the sail. Always get the throat up first, then "well the main-halliards," "well the peak," "belay all."

Should you require another pull of the peak-halliards, set them up by the purchase.

Send a hand aloft, man the mast-rope, sway up and unfid; then ease the top-mast down to within a foot of the sheave for the top-sail halliards; belay the mast-rope securely, haul out the stay, and set up the top-mast shrouds. Trim aft the jib-sheet, ease away the lee-lift and main-sheet; trim over and aft the fore-sheet, and get good way on the vessel.

You are now under single-reefed main-sail, whole fore-sail, and small jib; but the gale increases.

Let go the fore halliards, take in and stow the fore-sail, and sail her under reefed main-sail and jib. If the sea comes heavy, keep *good way on* her; luff a little, and enter her bow fairly to heavy *combers; then* fill away quickly, and drop her broadside on in the

trough; luff to the next comber, and repeat the dropping dodge again, always keeping good way on the vessel and working along a zigzag course; thus you will avoid straining the yacht or her spars, and, in all probability, you will not ship a cupful of water.

If it is necessary to beat up to windward to reach port, turn to and get a reef in the fore-sail, shift the sheets and tack, and set it, hauling up the weather-sheet and heaving her in stays. Haul down a second reef in the main-sail, and then get way on her again. If she plunges heavily, ease in the jib until the sheet just clears the fore-stay, and keep the main-tack triced well up.

Should the wind still increase, take in the close-reef, heave her in stays, and let the jib run in; ease up the bobstay, bowsprit shrouds, and top-mast stay; unfid and close-reef the bowsprit, then set up the bobstay shrouds, and stay again, and set the storm-jib. Now turn to and close-reef the main-sail and reset it; close-reef the foresail and set it; trim aft the head-sheets; batten down the fore-hatch and main skylights; get the dingy on deck, if not already in-board, and hammer her at it.

Storm Canvas.—Night is coming on, and the gale is hardening down and getting leaden-colored up to windward. The little vessel perhaps buries herself a good deal in the lee roll, which shows that the weight of the boom is telling on her; so get up the storm try-sail, which should be ready laced to the try-sail gaff with the sheets all bent. It may be fitted with straps and toggles along the luff, the strap having a man-rope knot at one end and an eye at the other, with the bight seized to the eyelet-hole in the luff of the sail.

When the sail is all handy, watch for a smooth, and luff her up with an easy sweep; haul the fore-sail amidships, the weather-sheet block just clear of the mast; ease up the jib-sheet handsomely, keeping it at full to lift her; lower away the main-sail, crutch the boom amidships, and haul taut and belay the sheets. Furl the sail, and stop it along; pass the boom-lashing, and haul taut and belay the lashing-tackles; see everything clear of the tiller, and that it works clear of the boom, furled sail, and lashings. Get the try-sail along, hook on the main-halliards, and hoist the throat up clear of the furled main-sail; make fast the jaw-parrel, hook on the peak-halliards, pass aft the sheet, hook it into its eyebolt, and mouse the hooks. Sway away on the throat and peak-halliards, toggle the

straps as the sail goes up, and ease the sheet a bit to humor the sail. Belay everything, clear the decks, and see all sheets and halliards clear for running; hard up the helm, trim the fore- and jib-sheets, and sail her a good "full-and-bye."

Balance-Reef.—In case you should ever be caught without a try-sail on board, you have two resources for after-storm canvas. One is to "balance-reef" the main-sail. A proper balance-reef in a main-sail is a series of eyelet-holes worked in the seams of the cloths from the leech-cringle of the close-reef to the throat of the sail. The main-halliard is eased down, the peak-halliards kept standing, and a lacing passed through the holes and round the close-reef, so that you have the peak of the mainsail standing up like the letter A on the boom. These eyelet-holes being now seldom seen, except in trading-cutters, a balance-reef must be made by lowering the throat and lashing it, hauling up the slack cloth tidily.

Jury Try-sail.—Another resource is to rig a jury try-sail, which may be done by using a spare fore-sail, making the after-leech the luff; work eyelet-holes in it with a marlingspike, and make fast a mast-lacing; hook the main-halliard to the head, storm-sheets to the tack, and tack-tackle to the clew, and you have your try-sail.

Wind Aft.—We must now take another point of sailing. Suppose, then, you had the wind dead aft, and were running before it, instead of being close-hauled.

In running off the wind, a vessel goes so pleasantly that you scarcely take any notice of the freshening wind until she begins to steer wildly, and threatens to gybe the main-sail over, which would be excessively dangerous to spars and gear, and an awkward proceeding at such a critical time. This position requires nice steering, as the head falls away in the trough, owing to the sea taking hold of her keel, and tending to throw her broadside on before the advancing wave. Meet her gently but firmly in anticipation; then mind, or she will take a sweep to windward, and threaten to come up broadside to This you must also prevent by meeting her in time. A quick eye and a ready hand will serve you well, and by observing to put the helm slightly down or up in advance of these movements, she will be easily controlled.

You have run on too far, and the sea is heavy and the gale too

strong to think of rounding-to for the purpose of getting her under storm-canvas.

Drop the peak of the main-sail until it is just square; in with the jib smartly, observing not to start the halliards until you have the foot secured; reef the bowsprit and set the storm-jib; then lower the fore-sail, close-reef and reset it. Make fast the weather topping-lift, lower the peak to the lifts, trice up the main-tack to the throat, and the main-sail is "*scandalized.*" Haul taut and belay the lee topping-lift, let go the main-halliards, and haul the throat down to the boom by the tack tricing-line; round in the main-sheet, lower away the peak, and stow the mainsail. Crutch and lash the boom, and set the storm try-sail; then away you go again.

We will now presume that the vessel is on her first course and snug, drawing near a port with which you are not very well acquainted. If at night, it is not advisable to enter the harbor, but keep plenty of sea-room and tack off and on shore until daylight; or, if you prefer it, heave her to with her head off-shore, the fore-sheet to windward, jib-sheet eased up, and main-sheet rounded in, keeping one hand on deck to attend the tiller, and another to keep a bright look-out for vessels, especially steamers.

Should the gale come on very weighty, take plenty of sea-room, and heave her to with *both* jib and fore-sheets belayed on each bow, and the sails trimmed right amidships. Should it be found necessary, stow the foresail and heave her to under the jib alone, having a hand at the tiller to humor her through the seas. A *sea* or *floating* anchor may also be rigged, and both the jib and foresail stowed.

Going into Port.—We have now daylight and may get into the harbor. Get the boat out, see the plug in, and lay the oars all ready for use; get the warping-line all ready should occasion require it; have a look at the chart and see what depth of water there is generally about the anchorage; get the anchor stocked, and cable shackled, ready for coming to.

When you are choosing a berth endeavor to pick a clear one, with room to cast from when getting under way again, and above all, anchor ahead of more weighty vessels than yourself, as, should they drive from their anchors they must come down upon you, when the superior weight tells, and their grief is your doom unless you can contrive to slip from the anchor and get under way; whereas, if you

drag down upon them you cannot do them much harm, and have something to heave a line to, to bring you up.

When you have picked your berth, see that there is a buoy made fast with a stout buoy-rope to the anchor, lower the fore-sail and stow it. If the vessel carries good headway in stays, keep her well to leeward of her berth, keep good way on, put the helm gently down and ease up the jib-sheet as she flies up in the wind; watch by the land when her headway ceases, and just as she begins to gather sternway, let go the anchor, pay out the chain handsomely as she takes it, and you will avoid a foul anchor. A good scope is from four to five times the depth of water.

When you are all right turn out all reefs and hoist the sails to dry if the weather be fine, if it continue wet and stormy make them up loosely for fear of mildew; shove the cork-boat fenders over the side to prevent the paint being injured by boats coming alongside; get the top-mast on end and properly stayed, all loose gear belayed, etc., get the bowsprit out, shrouds belayed, and bob-stay triced up out of the way of the cable; clear away the decks and have a good wash down, after which your little vessel will look as fresh as if she had not been battering away at the wild sea all night.

IN PORT.

ALWAYS have a look round the vessel yourself in the morning after breakfast; row off a short distance in the dingy, see that the topping-lifts, halliards, top-mast stay and shrouds, bowsprit-shrouds, all running gear, etc., are set well taut; that the copper is bright and clean, bulwarks and bends black and polished (if not let them have a coat of lamp-black and Japan varnish), ridge-ropes and man-ropes properly rove, the burgee and ensign chock up, and that the standing-rigging looks black.

Having satisfied yourself that all is correct from without, inspect the decks, see that the rail and forecastle flooring are as white as snow, all brass-work polished, accommodation-ladders over the side, with neat mats on deck for visitors to cleanse their shoes on, proper fenders along each quarter, all the halliard and tackle falls, main-sheet, etc., flemish coiled in their proper places, all skylights open *for ventilation,* and a wind-sail to the forecastle for the same pur*pose.*

White Decks. (Recipes, Etc.).—White decks are a great desideratum, and as they are generally covered with varnish during the winter, it is necessary to get rid of all traces of varnish and dirt.

Take of American potash, six pounds to every gallon of water, and boil it. When ready, dip into it a piece of white pine; if it colors the pine red at once, it is too strong, and requires the addition of more water. When it is the right strength, lay it on evenly all over the deck while quite hot. This must be done in the evening after sundown. Get to work in the morning before sunrise, and scrub it off carefully with deck brushes and fresh water; be careful that the sun does not get at it, for if it hardens on it will cause you endless trouble. Immediately afterward, holystone and scrub with sand. When the decks are thoroughly dried, apply a mixture of one pound of oxalic acid to a gallon of water evenly and lightly with a clean mop, and the decks will come out as white as snow. The latter mixture will also take out stains of oil or verdigris, if applied quickly.

The potash mixture will also clean all grease or oil off the copper; but, to get off verdigris, take one gill of vitriol to a gallon of water, apply this to the copper, and wash it all off carefully as soon as it fizzes up. Or the copper may be well scrubbed with sand and canvas.

Smooth jet-black bulwarks and bends add much to the smart appearance of a vessel; when coat after coat of paint is laid on, the results are great blisters and dull-looking paint. These coatings of paint should be entirely removed by heat, or by leaving the above potash mixture on about two hours, and then scrubbing it completely off. Next put on a couple of coats of priming, lead-color if desired, stop all inequalities with putty, rub the surface smooth with pumice-stone, then coat with thin ivory-black two or three times, rubbing it in with pumice-stone to prevent air-bubbles or blisters, and finish off with black Japan varnish.

HINTS ON HANDLING YACHTS.

WHENEVER you get under way in a racing craft, handle her exactly as if you had a prize in view. Start, if only for an hour's cruise, just the same as for a race; test every rope and spar, every clip-hook, block, and shackle in your gear. It is better to carry away the mast during a cruise than when you have just cleared a lot of clippers, and are *looking well to win* a cup. Better thus to get rid of a

bad bowsprit, a weak top-mast or rotten gear, than when you are involved in extra expenditure for additional hands, entrance fees, etc., which their failure will convert into dead loss.

See that every sail sets properly, work the vessel in all weathers, until you know the amount of sail she requires under every circumstance of wind and sea. Have all work done quickly and in silence, and allow no voice but that of your sailing-master to be heard.

As often as you can get alongside some vessel of known speed, or get a friendly racer to give you a trial—this is the time to get the ballast trimmed. Be careful that the jib and fore-sheets are so led, that when the vessel is close-hauled, the head-sail will make the same *effective* angle with the keel that the main-sail does. When you get the main-sail set to the greatest advantage, mark the halliards with a seizing of sail-twine, so that at any time you may know that the sail is properly set. Always have the main-halliards fitted with a purchase, which will be of immense advantage when the last inch or two is required. Try her carefully close-hauled, a couple of points free, with the wind abeam and quarterly, and when you discover how she likes canvas trimmed upon her on these points, mark the sheets with seizings of sail-twine. Have the main sheet fitted with a treble block at the boom, a double block at the horse, and single leading-blocks for the falls on each quarter; let the lower block always traverse on a horse, by which means you will get a more direct and powerful purchase on the boom when close-hauled.

Never, under any circumstances, start without *slinging the jaws of the gaff.* There is a tremendous strain on the main-halliards and blocks during a race, especially if the main-sail is cut with a high peak, so that often the block-hooks or halliards give way, and down comes the main-sail by the run, causing great confusion. The slings may be made of wire or chain, leather covered and having an eye at each end; then when the sail is set, pass the slings under the jaws of the gaff and lash the eyes together on the fore-side, over the eyes of the rigging. To get rid of them quickly cut the lashing, and the gaff is free for lowering. Be cautious when running before the wind, possibly with a balloon top-sail set, that the main-sheet is not eased off too far, so as to jamb the gaff against the rigging, or the first jump of a sea or puff of wind will carry it away.

Don't spare the crew in setting or taking in balloon-canvas until *satisfied that* they handle it as well as the usual working-canvas.

Balloon-sails are awkward to handle when adrift, and unless worked with lightning rapidity half the advantage is lost. Another great benefit of keeping a vessel up to the racing mark is, you need make but a slight increase in your regular crew for every match. Secure in the knowledge that everything on board is as tough and lasting as hemp, wood, or iron can be; that you have a skipper with the eye of an eagle, coolness of a stoic, tenacity of a leech, and heart of a lion; a crew active and silent, who know every rope in the dark and can tell whether a sheet or a halliard wants an inch one way or the other—all tried under your own eye, will cause you to feel that you can command success.

Balloon-Sails.

As much of the utility of balloon-canvas depends on the quickness with which it is handled, it is imperative that all the gear connected with it should be in perfect working order, and that the crew should be well practised in the handling of it.

A capital plan is to give the order to set one of your "kites," and note, watch in hand, the time required to do it. By repeating this several times you will see the improvement made by the crew and also get to know how much time to allow for setting, shifting, or taking in sail, and, when racing, can with confidence carry on the balloon-sails to the last moment.

THE BALLOON-JIB is a very large jib of light material, used only in light winds for going free; it generally extends abaft the main rigging.

SPINNAKER.—This is a large triangular sail of light material, which can be set in two ways. With the wind abaft the beam it is set from the top-mast head to the deck and boomed out on the windward side, this forming a very powerful sail, which enables a cutter to out-pace any other rig when running off the wind.

The other manner of setting it is as a balloon-jib, and in a light beam wind it becomes equally powerful and useful.

The boom should be fitted with an iron cap on each end, with a square hole for the shank of the goose-neck to fit into, which allows you to use either end at will. About a foot from each end a sheave should be *inserted, through* both of which the out-haul should be

rove, and the ends made fast together with a reef-knot. (Forward and after-guys are used to trim the boom.

A bobstay should be fitted with an eye over the boom-end, and passed under a *twisted* hook in the vessel's side, and thence on deck.

The burton is generally used for a topping-lift. The halliards should be rove through a tail-block made fast to the top-mast by the eyes of the rigging.

When using the spinnaker as a jib the tack must be hauled out to the bowsprit end by an out-haul (or lashed there), and it should be handled exactly like a balloon-jib, only, as it is larger, it requires more caution.

BALLOON TOP-SAIL.—A jack yard is now always used with a balloon top-sail, and to save an accumulation of spars the square top-sail should be made to set on it as on an ordinary yard.

The best-shaped balloon top-sail is one with a very high peak, resembling very much an exaggerated jib-headed top-sail.

It is a capital plan to have a peaking-line, rove through a sheave in the top-mast well above the eyes of the rigging. This is bent to the yard, about half way between the halliards and upper yard-arm, and causes the sail to stand flatter when set, besides being of great assistance in hoisting the yard and sail clear.

A bow-line should always be fitted to the luff of the sail.

BALLOON FORE-SAIL.—This powerful sail is of great value with the wind abeam or abaft the beam. Toggles or clip-hooks are fitted to secure it to the fore-stay. The sheets are fitted double and should reach well aft.

To set it.—See the sail clear, pass the sheets over those of the working fore-sail, outside everything, and make them fast well aft. Haul down the working fore-sail, shift the halliards, and hoist away, toggling the sail as it goes up. Secure the tack, and trim and make fast the sheets.

The sheet is sometimes rove through a tail-block well out on the main-boom. Keep one part inboard to facilitate taking in the sail.

JIB TOP-SAIL.—This is, correctly speaking, a stay-sail set on the fore top-mast stay. It is a most useful sail, but requires experience and caution in its management, to avoid carrying away the top-mast. The halliards should be rove through a block at the top-mast head,

and must be long enough to reach to the bowsprit end. The sheets should be of light line and fitted with a neat toggle.

To set the sail.—Bend on the halliards and sheets and get the sail to the bowsprit end. Set a hand-hoist handsomely, toggling it as it goes up. Secure the tack and hoist to the full height. Make the sheets fast at the best place for setting the sail properly, and let one hand stand by them. Care should be taken to set up the preventer back-stay well before hoisting the sail.

THE SHADOW.—This sail is intended to be an improvement on the spinnaker, and is to be used with the wind abaft the beam. It is set on a gaff which is attached by a goose-neck, to iron work on the fore-side of the mast, about where the jaws of the main-gaff rest. The iron work should be made so as to allow the top-mast to pass through it.

The length of the gaff should be such that when not in use, and hanging by the goose-neck, it may reach within four feet of the deck.

In cutters, and for the fore-masts of schooners, two halliards are necessary, one on each side of the fore-stay, but on the main-mast of schooners one will be found sufficient.

The sail is fitted with hoops which are slipped over the gaff, before hooking on the peak-halliards; when the hoops are all on, the head of the sail is brailed up close to the mast.

The gaff is then peaked up, and the boom, which is similar to a spinnaker-boom, is rigged out, and the foot of the sail set exactly as a spinnaker.

The extent of sail desired can be regulated according to the distance it is hauled out on the gaff. In very light winds, a jib-headed top-sail may be set above the sail.

From the gaff-end are guys, with which to trim it. When gybing, brail up the sail, lower the peak, unhook halliards and guys, pass the gaff under the fore-stay, shift the boom, hook on, and hoist away.

A Water-sail is only used when before the wind. To set it, an out-haul is used, in reeving through a block on the lower side of the outer end of the spinnaker-boom, and the sheet taken well aft, outside the bobstay; the sail is hauled out to the boom-end, keeping the tack taut enough to keep the sail out of the water.

Water-sails are found only in large yachts, and a good substitute may be made of a *jib-headed* top-sail.

A Ring-tail is set on the gaff and boom of the main-sail, when running before the wind. The peak down-haul may be used for a halliard, and a tail-block is made fast on the end of the boom for the sheet. Have a down-haul fast to the head of the sail, and an in-haul on the foot, to facilitate taking it in.

When hoisting, let a hand steady it with the down-haul to prevent its being twisted over. Run it up to the gaff-end before hauling it out. If the down-haul and in-haul are bent to the outer ends of the yards, they will serve for guys, and save extra gear.

Temporary Rudder.

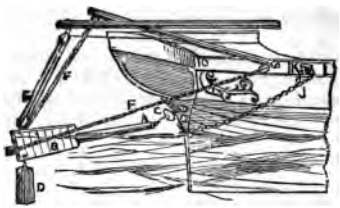


Fig. 1.

Fig. 2.

Pass the end of a chain down the rudder-trunk, and take it up over the stern; lash the end link to a piece of spar (A, Fig. 1) fitted with a blade (B); put a mouse (C) on the chain, leaving two or three links drift between it and the spar for play; sling a pig of ballast, or other weight, sufficient for immersion, at the lower part of the blade (D); fit a block (E) for a tackle to trice it up clear of the screw in case of making sternway; fit guys (F); lower the whole over the stern, and heave the chain tight until the mouse (C) is jammed tight in the lower part of the trunk (G); secure the chain (H, Fig. 2.), reeve the guys (F) through blocks at the end of a spar across the stern (I), and take them to the barrel of the wheel. When the main piece of the rudder cannot be unshipped, lash a large shackle to the end of the spar, and reeve the chain (J) through the shackle, drop the bight of the chain over the stern, and draw it tight under the counter, securing both ends in board at (K).

RACING.

Racing Preparations, &c.

IN the first place, I presume that all needful preparations in gear and sails have been completed, your entrance duly made, and fee paid.

On the day previous to a race it is advisable to get any of the cabin fittings, such as cushions, tables, seats, etc.—in fact, all articles not required for the working of the vessel—on shore out of the way. Next see that the commissariat is properly attended to; empty sacks won't stand, and hungry and thirsty seamen don't toil with a will when somewhat more than a good sea-drag is required upon some refractory sheet or halliard. A goodly piece of fresh beef and a block of cheese, with a fair allowance of ale, will answer the purpose in a satisfactory manner. Cooking on board during a race being out of the question, a cold stock must be the stand-by for all hands fore and aft.

As the ballast has been proportioned for racing-trim, do not neglect to start the stock of water out of the tanks. If practicable, the vessel should be gotten on the ground, and the copper carefully cleaned and smoothed.

See that no spare gear, anchors, odds and ends, scrubbing-brushes, etc., are stowed forward, or aft in the run. Everything that you must have on board should be placed in the main cabin, as the more concentrated you keep the weights, and the nearer the greatest breadth of beam, the better.

Get your course laid down by magnetic bearings on a sectional chart. Should it come on foggy or hazy, you will then know where to find the mark-boat by compass-bearings.

Note on your chart the hours of high and low water on the day, the direction of the flood- and ebb-tides, with their effects upon the course you are about to sail. If in strange waters, a good pilot is indispensable, but his attention should be directed to the pilotage alone; and if the skipper or hand of some local yacht, who has raced the course before, can be procured, so much the better.

Pay particular attention to the wind as affecting the different sides of the course—how much running, reaching, and turning to

windward may be expected. The pilot will give you an idea of what shifts of wind to look for, or whether you may count upon its blowing true throughout the day.

You may now take station at the starting-buoys, where you will doubtless find yourself in company with a number of rattling clippers.

We will suppose extreme cases, and that, instead of regular moorings being laid down, you are to start from your own anchor; so take position according to the number you have drawn, giving the vessel good way up to it, so that she may shoot well to windward; let go the anchor properly buoyed, and veer to a good scope until you drop exactly in with your competitors. Unshackle the chain near the bitts, bend on the breast-fast to the cable, outside of the hawse-pipe, then bend a spring-rope below that again, and lead it in round the quarter-timber astern, taking a loose hitch on the top transom; let the end of the cable run out through the hawse-pipe, and ride by the breast-fast alone. Get the boat on board, and the oars and gear all ready for service, then have her turned bottom up and lashed.

We will suppose that you are to start with a fair wind, the after-canvas set, the head-canvas to be run up between the warning and the starting guns. You have two miles of a run before the wind at the start, until you reach the first flag-mark, and then gybe-o; from thence to the second you will have the wind abeam for three miles, another gybe, and then a run of five miles with the wind abaft the beam, or quartering, to the leewardmost mark; after which you have a turn of ten miles for tacking—you may call it fourteen. Twice round this will give you a nice course of fifty miles. So now your work is all before you.

Hook the working-jib on the traveller, bend the sheets, and run it out, stopping it neatly along the bowsprit; lash the tack of the balloon-jib outside of all on the bowsprit-end, hook on the halliards, toggle the sheets, and let them lead well aft; put a lazy stop round the sail just outside the stem, to keep the jib out of the water.

See that the fore-sail is all ready for running up, the main-sail set to a nicety, the balloon top-sail aloft and clewed up, and run up the racing-flag to the mast-head in token that you are ready. Tail on all hands and get a good pull on the quarter-spring, easing away the breast-fast as you do so. This will bring the vessel broadside to the wind, but, whilst doing so, the main-sheet should be eased, to spill the wind out of the sail, or she will come up into the wind again.

Hark! there goes the first gun; you have now five minutes, so station the crew, the skipper to the tiller, the pilot to the main-sheet, the mate to the breast-fast, and a steady hand to the quarter-spring. These last to have each a sharp axe at hand, in case of necessity, to cut away at once. The remainder of the crew to the jib- and fore-halliards, and yourself to note, watch in hand, the fleeting moments.

As the last few seconds approach, round in a few feet of the main-sheet to give her life; as she bears upon the breast-fast, veer it away handsomely and heave in on the spring with a will. She is now moving in spite of you, but the last second is at hand; take a good slip turn of the spring, cast off the breast-fast, and pay out the main-sheet. Bang, goes the gun; up jib and fore-sail, slip the spring, trim the head-sheets, pilot look to the mark-boat, let go the clew-line and sheet home the top-sail. Select a hand to attend the jib-sheets, who must watch them as a cat does a mouse.

You have managed to get the lead and may select your own water, in doing which, look sharp as to how the tide sets in relation to the mark-boat; if it is setting across the bow from port to starboard, you should not keep dead on for the boat, which you have to leave on the starboard hand; keep her rather to windward of it, or she may be set on to the boat and foul it, thus losing the race; or else, in the endeavor to weather it, you must haul aft the sheets and luff up, which error would be turned to account by the other vessels.

On the other hand, should the tide be setting from starboard to port, it would be setting you away from the boat; and should you keep too high, you might have to gybe long before you reached it, which would give the vessels astern an advantage; and therefore, to avoid this, you should, from the start, keep well away to leeward, as if you were going to leave it on the port.

As a general rule, avoid a foul at any period of the race, by every means in your power, even if you have to run a few lengths out of the legitimate course, unless you are certain that a competitor is wilfully provoking a foul, then give him such a lesson as he will long remember.

You are now close to the mark-boat, which you must gybe round; and this is a proceeding which often requires judgment and determination. If the wind is steady and of average strength, with a smooth sea, you will have little difficulty, and can gybe with every-

thing standing; but, with the wind strong and puffy, and a heavy jumping sea on, your skill will be put to the test. Having plenty of sea-room and being well ahead of your competitors, your course properly would be to watch for a smooth.

But here you are hard-pressed, and must display a bit of recklessness which, under other circumstances, would be inexcusable. Clew up the top-sail, ease up the top-mast back-stay, slack up the weather-runner and tackle, all of which loop into a becket for the purpose, seized about four feet up on the after main-shroud; get the lee-runner and tackle hooked, and as the boom comes in let a hand set them up taut; let the fore and jib-sheets be trimmed over for the starboard tack, and let all hands tail on to both falls of the main-sheet. Now round in on the main-sheet, hand-over-hand, like lightning, humor her with the tiller until you see the leech of the main-sail flap over, and take a turn with the starboard sheet, sharp. Over goes the main-sail; pay out the lee-sheet, having a half-turn of the transom, and when out enough, belay; lead aft and set up the starboard top-mast back-stay; sheet home the top-sail, and trim all sheets most carefully. This manœuvre, with a little quickness and attention, can be performed with perfect confidence; both the ends of the sheet should not be belayed, as, if they are, a tremendous shock will ensue, probably resulting in the springing of the boom; much depends upon the helmsman, who can assist the men working the sheet, so that the boom may go over as easily as possible.

If by any chance the weight of the jib should overpower the men at the running-end of the sheet, put the helm hard down, and let the vessel run up in the wind; when the wind will be spilled out of the main-sail, and all risk of carrying away your boom or gaff avoided.

Fairly on your reach, see that every sail is doing its duty, particularly that she is not bound by the head-sheets, and that the tack-tackle is not too taut. Let every sail draw well; the fore- and jib-sheets should be well eased, and a few inches of the top-sail sheet may be of advantage too; berth your crew amidships, sitting, and let there be no jumping about. When anything requires to be done, select the hands to do it, and let them creep along to their work.

You are now bowling along at a rattling pace, and have time to *look about you*; there will be generally one of your antagonists, or *perhaps two*, whom you must keep a very sharp eye upon; I will

assume that you have only one of a speed causing you serious apprehension, to simplify matters. If you are reaching along shore, and observe that he stands in close, look out that there is neither slack-water, nor a favoring tide, which he is seeking for. Your pilot ought to know these secrets, but never quit this antagonist, except straight on end, for whatever advantage he gets, you may have the same, and if you meet with a check he suffers from it likewise.

Should you find that the sternmost vessels are drawing up on you, look out, for your rival may be doing you a mischief as well as himself; by all means do not permit him to get to windward of you, for if his sails once cover yours he may hold you under his lee for miles. Always get the weather-gauge if you can, and keep it until circumstances force you to yield, and then keep your eyes sharp about you to regain it.

Suppose now that squalls come sweeping along; if you have a good lead, be cautious and ease your vessel to them, by clewing up the top-sail, tricing up the main-tack, and lowering the fore-sail; but, if the vessels are too close upon you, and are carrying on, you must carry on also. As a general rule, in squalls always work your vessel to windward of her course, when there are no tides to be taken into account.

You approach the second mark-boat, and here you have to gybe again. You have now a long run before you, and it will be a favorable time to "make the sun over the fore-yard," and serve out grog in moderation. Now take a look round; see the main- and peak-halliards, jib purchase, etc., well taut—in fact, freshen up all round.

As you near the seaward mark-boat, prepare for hauling by the wind; carry on until the last moment, then make quick work. Your balloon-jib must come in; send a hand to the bow-sprit end, trim aft the fore-sheet, and have two hands ready to clasp the sail in their arms as it comes in.

Now let the man on the bowsprit cut the seizing, *being careful to have a firm hold*, or the violent *jerk of the bowsprit will cant him into the water;* the last strand parts, in flies the jib, lower the halliards, unbend the gear and shove the sail below through the skylight. The man on the bowsprit has cast off the stops of the working-jib, so run it up and trim aft the sheet. The top-sail must next be attended to; if the tack is to windward, clew up the sail and haul it down at once; but should the tack be to leeward, keep the sheet stand-

ing, send a hand aloft, and let him shift the tack over to windward; haul it well aft, easing the halliards as you do so; let the man aloft now shove the foot of the yard over the peak halliards and to windward of the top-mast—the hands on deck helping it from below by easing the top-sail sheet, and the moment it is clear, clew up and haul down. If you have a high-peaked, well-cut, and flat-standing gaff top-sail, by leading a bowline through a tail-block at the bowsprit end, and having a long bowline bridle with the ends set to thirds of the luff of the sail, you can make it render excellent service in light winds, when you need every stitch to woo the fickle breeze.

I will suppose that you are round the leewardmost flag-boat; everything is braced sharp up for a regular hammering match to windward, and your principal antagonist is racing beam and beam with you. Take a look at the halliards, see the jib up taut; if the luff is slack, get a good sea-drag upon the purchase while you are in stays; the peak may be better for a small pull—it will lift the boom off her quarter; so haul the weather topping-lift taut, easing a few inches of the main-sheet as you do so; then get a steady drag upon the peak-purchase; ease away the lift again and see that the main- and fore-tacks are well boarded; be careful that the vessel is not bound in any way, but is going along freely and with life in her. Let the crew lie down under the weather-rail amidships; see that no spare gear is trailing overboard; watch every puff stronger than usual, and wedge her up to windward during its strength; keep an eye to the luff of the main-sail—if that shakes, you are shaving too close. Let the head-sheets be tended as the apple of your eye; you may have to humor her with them if the wind falls light.

In fair average weather, when you go about, never back her off with the fore-sail; let both head-sheets go over at the same time unless you have a very heavy head-sea on, and then keep the weather-sheet up only for the moment. If you are reefed down she may require it a little longer, owing to the low and shortened canvas. You are now closing up with the weathermost flag-boat, which you have to leave on the port hand.

The first who rounds that boat will get a tremendous lead; so don't tack for it until you are sure to weather it, which will be when it bears well abaft your beam, providing no tide is affecting you; if *there is, you* must allow for it by bringing the mark farther abaft, or *forward, as circumstances* may require. On you go; you are round

the boat and flying away off the wind with your working-jib stowed, balloon-canvas going up merrily, and have secured a rattling lead.

Now that one round is completed, have a careful look round, give all hands a bite at the beef and biscuit, and commence the second round with a fair reaching wind as before.

But, how is this? Our hardy antagonist is holding on just as he was while beating to windward, and, instead of bearing away, he is hauling up to windward of the course. The breeze is lulling—now a little fitful puff, and then another lull; there is a glassy streak along the water and little clouds are rising ahead, while under them appears a dark ripple. You remember that such things as shifts of wind occur, particularly toward the afternoon as the wind comes round with the sun. This is one, sure enough, and it comes dead on to your course.

The vessel is all upright in a moment, and the canvas shivering and rattling like mimic thunder. Your antagonist is far to windward, and can lay his course for the second mark-boat, while you are dead to leeward and must make several tacks to weather it.

But it is not too late; so round with her on the port tack, let two hands get under the lee of the fore-sail to clasp the balloon-jib, let go the tack, and the sail will fly in. Meanwhile other hands have got the working-jib; toggle the sheets, bend the halliards, hook the traveller, and set it at once. Next get the balloon top-sail down, and then everything is snug, and away you go close-hauled, the men berthed low, every sail setting flat and tended jealously. The sails may now be wet, if not new, and they will hold the wind better, but observe to wet them evenly, not a spot must be left dry to girt the sail. Wet the jibs or top-sails you are about to set, before they leave the deck, then look out as they dry to freshen the nip on the gear.

Now for your antagonist. You are on the port-tack and closing up under his lee; he is crossing your bows on the starboard tack, and has wrested the lead from you. You are now crossing his wake and he is laying to weather the mark-boat, but barely. You have beaten him before on a wind, and it is fair to suppose you can do it again, and weather the mark whether he does or not. It is doubly imperative on you not to leave him now, so go about at once on his weather-quarter—and there's a fresh puff to give you a lift to windward. Ho! there's a bang. What's that? Why, it's your bobstay carried away! Let a hand creep down and haul hand taut the lee

bowsprit-shroud tackle; ease her with the jib-sheet: a few inches' slack will not hurt her much, and save your stick. He is on for the mark; but see! the tide has caught him and thrown him to leeward; you are to windward of him, so now or never. Away you go for the boat; the tide has you, but don't flinch yet; the bow of the mark-boat appears on your weather-bow—the mast—her whole hull; never mind, if you are close to her; keep good way on for your life; shove your helm down; let the vessel run up in the wind—there you go flying by the mark-boat on a capital *half-board* until you are clear; now ease away the main-sheet, up helm, and away you go with the lead again.

Get in the working-jib, repair the bob-stay, and set the balloon-jib and gaff top-sail. Now is your time to make the running. If you have the wind abeam and light, and the clew of the jib reaches aft to the rigging, lower the fore-sail and let the jib do all the work (or a spinnaker may be used).

If the balloon-jib sheet be led through a tail-block at the main-boom end, the clew will be lifted well up, and, if the wind is varying, both main-sail and jib can be humored with the main-sheet.

Get the working-jib made up and stopped with split-stops, so that a slight jerk will clear it; hook it to the traveller, toggle the sheets, hook the working halliards, and run the jib out and stop it on the bowsprit, ready for setting the moment you round the leewardmost mark, for as you draw out seaward the wind is drawing out too, and has reached its old point, giving you another beat home instead of a reach.

You have obtained a commanding lead, but be cautious—there are active crews and fast vessels astern of you. Holloa! look out for the gybe!—heads all! crash! bang! Top-mast is gone, short off by the mast-head iron; get the head-sheets over and trimmed, and trim the main-sheet with the wind quarterly! Look alive, now, all hands, and secure the wreck under the boom, on the lee side; get hold of the tack and secure the top-sail, let go the sheet and haul down; cast off the tie from the yard, the tack and sheet from the sail, and get in and stow away the top-sail. Knock the truck and rigging off the spent top-mast; cut the racing flag clear and send a hand aloft to lash it to the stump. If the top-mast be not too much splintered it may be sent up as a jury-spar and a small jib-headed top-sail carried, which will tell turning to windward.

The last sea-mark is now at hand. Keep the vessel off the wind, and get in the balloon-jib, and, as the wind has settled down to a steady, snorting breeze, you may stow it below. Up with the working-jib smartly, trim aft the sheets, luff close round the mark-boat, rounding in both falls of the main-sheet as she comes up until it is trimmed by the wind; see the halliards up taut, board the tacks, berth the crew low, and use all your skill.

Sail her boldly, making every inch you can, and working the sheets in stays like clockwork, so that there shall be no stoppage for a moment. Luff to every puff stronger than usual, and you will gain many a length in the wind's eye. Make sure work while you can, for you may require every hair's-breadth of vantage you possess.

Here comes a heavy puff. Oh, oh! what jerk is that?—weather bowsprit-shroud gone—'bout ship at once to save the bowsprit! If the sea is not heavy this damage is easily repaired; but should there be too much water to risk men on the bowsprit, get the lashings and spare rope ready, run her off the wind for a few moments and make sharp work of it. If the accident occurs close to the flag-boat, and the weather is not too heavy, you may carry on, easing in the jib half way and trimming the sheet farther aft. You are all right again, and have the race still well in hand; so now for the last tug. She is lifting to heavy combers and going along like a witch. But eh! Steady, what is wrong now? "Fore-stay gone in the nip!" Up helm, sharp for your life, before the mast comes tumbling aft; slack up and unhook the runners and tackles, pay out the main sheet handsomely and run her off before the wind; let the fore-sail run down, bring the runners and tackles forward under the eyes of the rigging, and get a stout strap passed round the bowsprit outside the stem, clear of the head-gear. Hook on the lower blocks of both runners and tackles, and set them up taut. Toss the boom up with the weather-lift; it will ease the dead weight of the sail a bit. Another pull on the tackles and belay. Haul her by the wind again, slack the lifts, and trim the main-sheet; toggle the reef-tackle some four feet up the broken stay, and set it up well to help the runners; lace the fore-sail on again above the tackle, and run it up.

You have the leading tack still, and you deserve it, and although I have imagined all these disasters for you, and could inflict more upon you, I hope none of them will ever befall you; so I leave you at the flag-ship, *enjoying the hearty* cheer which always welcomes the

hardy yacht and daring crew that never succumb to difficulty, or allow a thought to damp their determination to sail and win.

Varieties of Starts.—There are three methods of starting yachts for matches, each of which is peculiar to different yachting stations.

The first is starting from "loosened canvas"—that is, the gaskets are off the main-sail, the fore-sail is ready for running up, and the jib hooked to the traveller, sheets and halliards bent, so that when the starting-gun is fired all the canvas has to be set. On the day previous to the race the main-sail should be well overhauled; the seizings closely passed, head-earing well hauled out, and gaff-lacing passed afresh. Let the mast be greased, and the patent-rollers of all blocks oiled; also the top-mast, gaff, and bowsprit sheaves. When the main-sail is ready for running up, see that the top-sail sheet is all clear, the ensign-halliards and main-tack tricing-line also. With double topping-lifts, unhook that which will be the lee one when under way, to facilitate hoisting the sail clear.

As a general rule, two guns are fired at an interval of five minutes: the first to prepare, the second to start.

At the first, station your crew: the helmsman to his tiller, two hands to attend the breast-fast and quarter-spring, and the rest to the halliards; have the head-sheets belayed on the bow you are going to start from, so that as the sails go up they may catch and pay her head off on the proper cant. Let the main-sheet be eased off to its proper trim (I assume that you are to start to windward), in order that she may not be brought head to wind as the sail goes up. Note by your watch as the minutes expire, and as the main-halliards will be the heaviest pull, let two of the head-halliard men jump aloft and be ready to ride down the main- and peak-halliards, cast off the breast-fast at the flash and allow her head to pay off, but keep the quarter-spring belayed. Instantly the men aloft swing to the deck let them man the head-halliards; the peak will be by this time high enough for setting the main, so take a turn with the peak-halliards and put the men at the throat-halliards. Cast off the quarter-spring. The throat of the main-sail being up, finish setting the peak, jib, and fore-sail, and set the gaff top-sail; berth the crew to windward and let two hands clear the decks, coil the falls clear, and lead the sheets along to the body of the crew.

Whenever a pull is required, get it while in stays if you are to tack

soon; if not, let the men creep cautiously to the falls, hold your hand up to the helmsman, and let him "luff and touch her;" then a good steady drag, and everything will go home.

The second mode of starting is with the after-canvas set previously, and head-sails down until the starting-gun is fired. As this method has been already noticed, it is unnecessary to recapitulate it here.

The third method is the "flying start," which is now the generally adopted plan whenever the nature of the starting-point will admit of it. The usual manner of starting is as follows: A preparatory flag is hoisted on board the commodore's vessel, or at some other convenient place, which is allowed to fly until the appointed starting hour, then a gun is fired and a different colored flag is hoisted; five minutes later another gun is fired, when all the yachts start together.

The yachts are usually hove to in a cluster near the flag-ship before the start, and are required to pass between the flag-ship and a flag-boat moored at some convenient distance, when the starting-gun fires.

This method of starting is much the fairest, as all start together, under the same conditions of wind and tide, and although the smartest handled yacht will doubtless get the advantage in getting away the first at the start and taking the windward berth, it is only just that such should be the case, and that skilfulness and good seamanship should be rewarded.

Should it be blowing pretty fresh, take position as much to windward and as close to the flag-boat as will admit of your just shoving her to leeward. Heave to with fore-sheet to windward, and by backing and filling, check her in the chosen spot. If you have previously determined that all play to windward must be made under the lower sails, have the topmast housed. Should the first stretch be off the wind, however, the topmast may be kept up and a gaff-topsail set over a reefed mainsail. This will enable you to press your vessel on the run to leeward, and previously to hauling by the wind, by lowering the topsail and housing the topmast she will round-to under snug canvas. It is easier to make sail than to take it in during blowing weather, and you can shake out reefs in one-fourth the time it will occupy to take them in. It should always be borne in mind that alterations of canvas during a race now-a-days are made while she is under way, for there is no time to heave to.

The state of the tide must be well considered; if there is a strong tide running *against a light* wind, and you are to beat down a chan-

nel, you may carry a jib and top-sail with great advantage, for the tide carrying you bodily to windward you require all the canvas you can show to keep good way on the vessel, which should always be kept in the full strength of the tide. With a strong wind and moderate tide, both against you, be careful of too much head-canvas, but carry a square-headed gaff-topsail.

Under these circumstances a good helmsman will feel his way, and by the pressure of the tiller and the working of the vessel, tell as he reaches into or out of slack water, every foot of which should be utilized.

Corinthian Races.—These are becoming every year more numerous, and are more interesting both to the participators and spectators than ordinary races are. Every yachtsman values a cup more highly when it has been wrested from other yachts by the superior management of himself and his chosen friends.

If you are going to race your own yacht, you will doubtless take the tiller, if you have confidence in your own steering; if not, get a friend with a reputation as a helmsman to guide your vessel to victory, and be content to take a mate's berth, or work as a deck-hand.

Although it is of vast importance that a yacht should be well steered, it is also necessary to have a good mate, one who can set a sail and direct others how to do it, and can ensure prompt obedience to his orders.

Should you be able to do so, it is a capital plan to take your amateur crew out a few days before the race, and let them work the vessel so as to get the run of the gear.

On the day previous to the race, go as near the starting-place as convenient for anchorage and reeve all the racing-gear. See all balloon-gear shipped and that everything renders easily in the blocks. Examine the standing rigging, and have a preventer on the bob-stay. See the preventer back-stays all clear and that their tackles are long enough to reach the proper ring-bolts. Send all spare gear on shore, and then overhaul the balloon-sails, and stop them neatly, all ready for stowing in their proper places.

On the morning of the race, be up early. Get your racing flag, fix it on a small staff, and lash it to your top-mast head.

If the morning is fine set your main-sail and top-sail, reeve reef-pendants and, if likely to be needed, bend on your reef-tackle, and

stop it along the boom. Get out the balloon-sails, and stow all handy for use. If the wind is light, get the large flying-jib to the bow-sprit and set it, then stow it. If unable to carry the large one use the small one, unless the wind is too strong.

Get the jib you intend using, and hook on the halliards and traveller, toggle the sheets, haul out to the bowsprit end and stop it with a gasket.

Stow the spinnaker at the bottom of the fore-hatch. Next get the balloon fore-sail, bend on the sheets, and stow it on the floor of the forecastle, head uppermost, forward of the spinnaker. Have all the jibs laid all clear in the main cabin where they will be handy. Bend the balloon top-sail on the yard and jack-yard, and if not at once set, make it up and stow it along the deck. Get your working or jib-headed top-sail all ready for immediate use. If you are to start with a dead run to the first mark-boat, ship the spinnaker-boom on the proper side, and top it up alongside the mast.

Should the wind be too strong to admit of your carrying a whole main-sail, put in as many reefs as may be necessary. If single-reefed set No. 3 jib, double-reefed No. 4 jib, and reef the bowsprit. With three reefs use No. 4 jib, one reef in the fore-sail and double reef the bowsprit. Should this sail not be short enough, you may close-reef the main-sail and fore-sail.

With a reefed main-sail or whenever you cannot carry a top-sail going to windward, house the top-mast. When running off the wind, however, keep the top-mast up, and set a jib-headed top-sail over the reefed main-sail.

Whenever the top-mast is housed and the distance to run is short, the balloon-jib may be set from the mast head and boomed out on the spinnaker-boom.

Station the Crew.—Your mate must be forward to work the jib-sheets, attend to the head-sails and exercise general supervision. With him another hand should be stationed, and one of these two should keep a sharp look-out to leeward.

Place a hand at each fore-sheet who will also attend the boom topping-lifts when tacking. When gybing have a hand at each preventer top-mast back-stay, who can also attend the runners.

When beating to windward send everybody up under the weather bulwark.

If you have to shift sails, be smart about it and have the one you are about to set all ready before taking in the other. To avoid mistakes in bending gear, and to find the head of a sail in the dark, remember that the canvas is sewn on the right-hand side of the bolt-rope.

Allow no others to give orders, preserve silence, and insist on each man remaining at his post.

If the wind is light you will have set your balloon top-sail on the side you intend to take it in on when you get on a wind.

Down to the lee flag-boat you will carry your boom on the starboard side, then you must gybe, for you have a beam wind from there to the second mark-boat. Therefore the top-sails should be hoisted on the starboard side. Should you not do this you will require to dip the tack and get the yard to the other side of the mast, which will lose valuable time. Get under way, unstock and unshackle the anchor, and stow it on the floor of the cabin. As the hour for starting approaches, get your boat on deck and stow it wherever it is least in the way.

Keep a sharp look-out for the first or "five minutes" gun, and as the wind is light keep dead to windward of the course. Let the timekeeper tell you each minute after the first gun, and during the last minute let him say, "Half a minute to go," "Twenty seconds to go," or "Ten seconds to go," so that you may be prepared.

It is a good plan to have sand-glasses made to run five minutes, and so graduated that the steersman can see exactly how much time remains before the second gun fires. The glasses for all the yachts can be timed by the one used by the club-starter, and all mistakes from careless timing avoided.

Have the spinnaker-gear bent and ready for use, lower the boom and get the guys fast. Lower the fore-sail, as it will do you no good before the wind, and you have more room on deck when it is down. And see the starting-gun flashes just as you come up to the line, and you are first away with a windward berth, so run your spinnaker up to the top-mast head and out with it to the boom-end, and away your little craft bounds with a cloud of white canvas from truck to deck. As you get near the lee mark-boat prepare for a gybe. Get the spinnaker in in good time. Don't keep too close to the flag-boat, as in gybing your vessel will make a sweep; therefore keep well to the leeward of it, about three or four lengths will do, and let her come round gently to ease the jerk and to give time for round-

ing in the main-sheet and hooking on runners and preventer-back-stays. If there is another yacht close astern, take care you do not allow yourself to be jammed so close to the mark-boat that your opponent is able to cut across your stern and so luff up to windward of you.

As soon as you are round, run up your flying-jib and balloon foresail for the reach, and make a man stand by the sheets and watch them carefully.

And now that you have made such a good start and have safely rounded the first mark-boat ahead of all opponents, I leave you to fight out the battle, wishing you perfect exemption from accidents and the success which a smart yacht, actively and judiciously handled, is certain to achieve.

Laying Up.

At the end of the season you will require to dismantle and lay your yacht up for the winter months.

Take advantage of a fine day to get all sails perfectly dry before unbending them, and on no account stow them away damp, as mildew will certainly attack them. As you unbend make them up neatly, stopping them with manilla yarns, and stow them in a dry, airy loft, where they can be opened out occasionally.

Next, send all cabin fittings on shore. Unreeve all running-gear and store it with the sails. Send the spars on shore if possible, or, in case of stowing them on board, store them clear of the deck on dunnage.

If the yacht is to remain at moorings during the winter, knock out some of the mast wedges to allow the air to pass, and put a canvas cover around the mast to keep the wet out. Ease up the rigging a little; coat the mast well, and give the deck and fittings two thick coatings of varnish or shellac. Take out enough ballast to make her float light, and to allow her to dry as much as possible.

Whenever it can be done, a yacht should be hauled up high and dry, in which case she can dry thoroughly, and, the ballast being out, you can clean and whitewash her internally, which will preserve the wood. Each piece of ballast should be marked as removed, so that it may be replaced exactly when restowed, in order to preserve her proper trim.

Should you leave your yacht afloat, be careful to so arrange the moorings as to prevent much alteration of her position from swinging or other causes.

A secure plan is to lay out three anchors in the form of an equilateral triangle, uniting the chains to a bridle which is led through the hawse-hole and made fast to the bitts, or windlass. But in case you have not so many anchors to spare, use the ordinary working anchors, placing the heaviest one in the most favorable position to withstand the effects of the strongest prevailing winds.

Should your skipper be employed by the year, of course he can attend to the yacht during the winter; but if he is not retained, an arrangement must be made with some one to look after the vessel and open the skylights in fine weather.

Refitting.

If the yacht has been hauled up, the mast and ballast will probably have been taken out, in which case restep the mast and replace a little ballast before launching.

But, whether she has been hauled up or left at moorings, all ballast should be replaced before commencing cleaning.

Send a man aloft in a boatswain's chair to scrape the mast from the head downward. Get all the spars, blocks, mast-hoops, and cross-trees nicely scraped and varnished. When the varnish is hard, and the spars in place, go over them with sand-paper, and revarnish twice; you will then get a beautiful surface. The first coat serves to fill the inequalities of the surface and assist the sand-paper in giving the polish.

Examine carefully the eyes of the rigging, and re-serve them if necessary. Renew the lanyards in case they are not perfectly sound. Set up the rigging, replace the mast-wedges, and cover them with canvas

Reeve all running-gear, examining it as you do so, and renewing it where required.* Get the cabin fittings on board and see everything ship-shape below.

* It is a good plan to use three sizes of line for all running-gear, as there is then very little waste, and, as your blocks will be made for those sizes, there will be no trouble about gear refusing to render, or jambing in the blocks.

Now give the decks two or three good cleanings with potash and hot water to get them white; scrape the inside of the bulwarks, rail, skylights, and all deck fittings, and varnish them.

Finally bend sails, paint the yacht outside, and get the boats done up.

Four-stranded rope, sometimes called "yacht cordage," looks neat, runs with ease through the blocks, is pleasant to handle, and is recommended in preference to three-stranded rope.

New rope should be well stretched before being used for halliards.

When halliards get worn or chafed, turn them end for end.

QUESTIONS AND ANSWERS IN FORE-AND-AFT SEAMANSHIP.

Cutter, Sloop, and Yawl Rigs.

(*Rosser.*)

Q. What is a cutter rig?

A. One mast, bowsprit fitted to run out and in, and jib set flying; the chief sails are fore-and-aft main-sail, gaff top-sail, fore-sail, and jib.

Q. What is a sloop rig?

A. One mast and fore-and-aft sails like a cutter, but a standing bowsprit; the jib is set on a stay leading to the bowsprit, she sometimes sets a flying jib on a jibboom.

Q. What is a yawl rig?

A. A fore-and-aft main-sail, gaff top-sail, fore-sail and jib, are carried as in a cutter; in addition there is a small mizzen-mast stepped in the stern, upon which is set either a lug or sprit-sail called the mizzen, the sheet of which is led to the end of a horizontal spar projecting over the stern; the foot of the main-sail is shorter to allow the boom to traverse clear of the mizzen-mast.

Q. How many shrouds on a side are usually fitted in these rigs?

A. Three or four in a large craft, two in small vessels.

Q. Any other gear?

A. Yes, a runner and tackle with pennant on each abaft the rigging.

Q. To what portion of the hull is the fore-stay secured?

A. To the stem-head in a cutter. In a sloop the fore-stay generally leads to the end of the bowsprit.

Q. Do fore-and-aft vessels often house and send up their top-masts?

A. Yes, and for this purpose a mast- or heel-rope is kept rove in readiness.

Q. What precautions are generally taken to prevent the mast from falling when housed, in addition to keeping the mast-rope rove?

A. The bight of a rope (about two or three fathoms long, with an eye spliced in each end) is seized on to an eye-bolt, on the heel of the top-mast; the ends of the rope are seized on to the foremost shroud of the rigging, one on each side, so that when the mast is housed, the legs form an angle of about forty-five degrees with the heel of the top-mast. This is generally a fixture, sufficient drift being allowed for the mast to be

housed or sent aloft, without taking the seizings off, a lashing round the heel of top-mast and lower-mast does just as well.

Q. How is a cutter's top-mast rigging fitted?

A. It is cut short so that it can be set up when the top-mast is lowered without putting a sheepshank in it.

Q. Describe it?

A. It is led from the top-mast head through a score in the outer arm of the cross-trees, below which, and in the end, a thimble is spliced. From this to the channels of the rigging it is set up with a tackle. Short lengths, called legs, fitted with clip-hooks or shackles, are used to give the required length when the top-mast is sent aloft.

Q. How is the bowsprit supported?

A. By means of a bobstay and shrouds.

Q. How are they fitted?

A. With two single blocks, or a runner and tackle. Shrouds have the tackle on the inner end; bobstay, the tackle on the other end, with a line on the bight to trice it up with when required. The standing part of the bobstay is generally chain, that of the shrouds wire-rope.

Q. How would you reef a cutter's bowsprit?

A. Slack up all the gear. Reeve a heel-rope and heave taut upon it, and take out the fid. Slack the bowsprit into the second or third fid-hole, as required, ship the fid, and then set up the gear.

Q. What are whiskers?

A. Two iron rods placed on each side of the stem to extend the spread of the bowsprit shrouds in sharp-bowed vessels.

Q. How are the topping-lifts fitted?

A. Single or double from the mast-head to the boom-end (in small vessels).

Q. Describe them.

A. The standing part is hooked on to the boom and led through a block on the cap at the mast-head, from thence on deck, and there set up with a runner and tackle. Double ones are fitted with the standing part on the cap, and led thence through a single block at the boom-end and back to a block at the cap, thence to the deck. In large cutters a single one is fitted on each side of the boom, and rove through a block under the eyes of the rigging. The lee one is overhauled slack, or unhooked, to keep the chafe off the sail when set.

Q. How are the peak-halliards rove?

A. Through two blocks on the gaff, and three at the mast-head. The standing part has a tackle on it with about three to four fathoms drift between the blocks when overhauled, which tackle is hooked on to an eye-bolt abaft the rigging and called the peak-purchase. The hauling part is led from the lower block at the mast-head to the deck.

Q. How is the peak-line rove, and what is it used for?

A. As a single whip through a small block at the gaff-end. Used for hoisting the ensign or signals, and for hauling the gaff down.

Q. How is the luff of the mainsail bent?

A. Bent on to hoops round the mast, or with hanks from the throat down to the third reef, from thence there is sometimes a lacing.

Q. Why?

A. To trice the tack up, or take the reefs in with greater facility, by slacking up the lacing or unreeving it.

Q. How are the reef-pennants of the main-sail fitted?

A. With a wall-knot or Matthew Walker on one end.

Q. How are they rove?

A. From down up through the cleat on one side of the boom, through the corresponding reef-cringle on the after part of the sail, and down through the sheave on the other side of the boom.

Q. How is the fore-sail fitted?

A. With hanks on (or by a lacing to) the fore-stay. The halliards have two single blocks with clip-hooks for hooking into the thimble in the head of the sail. The sheet sometimes travels on an iron rod or horse across the deck. A bowline bridle on the after leech, with a line to the fore-mast shroud is used to keep the sail to windward when necessary.

Q. How are the jib-halliards rove?

A. Through two single blocks with a purchase on the standing part, same as the peak-halliards.

Q. How would you set a jib?

A. Hook on the halliards to the head of the sail, the tack to the traveller, shackle on and belay the sheets slack, then haul the tack chock out, hoist away on the halliards, and haul aft the sheet.

Q. How is the gaff top-sail sheet rove?

A. From the deck through a block under the jaws of the gaff, from thence through a sheave or a block at the gaff-end.

Q. How would you take a gaff top-sail in?

A. Lower the halliards, and haul on the down-haul, until the head of the sail is down to the cap of the mast-head, hold on the halliards, let go the sheet, and trip up. When the sail is clewed up, let go the halliards, and haul it down by the tack and down-haul. Always take it in to leeward of the main-sail if possible, because there is less chance of its jambing.

Q. How is the gaff top sail down-haul fitted?

A. The standing part on the clew of the sail, and through a single block on the head of the sail (if it is jib-headed); if set with a yard on the head, the block is on the inner yard-arm.

Q. How would you set a square-sail?

A. Lower the fore-sail down, hoist up and square the yard, bend on the yard-arm whips to the earings, and the fore-sail halliards to the middle of the head of the sail, hitch the lizard on the jumper to the mid-ship halliards, hoist up and trim. A down-haul is bent on to each halliard. In modern yachts the sail is sometimes bent to the yard, which is hoisted by the fore-halliard, lifts being dispensed with.

Q. How would you take it in?

A. Keep the tack and sheet fast. Slack off and haul down outer halliards as low as possible. Then let go midship-halliards, haul on the down-hauls, and gather in the sail to leeward of the main-sail.

Q. How would you reef a main-sail?

A. Lower throat- and peak-halliards sufficiently to take in the reef required, hook on reef-tackle to reef-pennant, and bowse the reef-cringle down on to the boom, pass the tack-earing, tie the reef-points, and reset the sail, hoisting throat taut up before the peak.

Q. How would you take in the balance-reef, the third and fourth reef being in?

A. Ease the peak sufficiently to allow the jaws of the gaff to come close down; when closed down past throat-earing, and hook on tack-tackle, reeve the points, tie them and set up the peak-halliards.

Q. Suppose your main-sail has no balance-reef?

A. Then lower the jaws of the gaff as aforesaid and lash the leech of the sail round the boom.

Q. What is scandalizing the main-sail?

A. Tricing the tack up, and lowering or dropping the peak.

Q. Where does the boom-guy lead to when running before the wind?

A. Outside the rigging, and in board, to the fore part of the bowsprit-bitts.

Q. What is a jib top-sail, and how is it set?

A. A light sail set from the bowsprit end to the top-mast head. Sometimes it is bent on hanks to the top-mast stay.

Q. What is a balloon-jib?

A. A large jib of light make, used only in light winds for going free; it extends from the bowsprit end to the main rigging.

Q. What is a spitfire-jib?

A. A very small jib of No. 1 canvas, for stormy weather.

Q. How would you shift jibs in a gale of wind?

A. Get the sail up from below, lay it along the weather side of the fore-deck with the head aft. Then haul the fore-sheet to windward, round in on the main-sheet, trice up the tack and becket the helm. Let go the jib out-haul, sing out to stand by! and the sail will fly in along the bowsprit, muzzle it, let go the halliards, and haul down. Bend on the sheets to the spitfire-jib, hook the tack on the traveller, and the halliards to the head, pass a couple of rope-yarns round the head of the sail. Haul out the traveller to its proper place; belay the out-haul, make fast both sheets slack, hoist up, let draw fore-sheet and trim aft your jib-sheet.

Q. What canvas would you reach under, in a gale, with a heavy sea?

A. Trysail, double-reefed fore-sail, and storm-jib.

Q. What canvas would you heave to with, heavy gale and sea?

A. Try-sail and storm-jib, top-mast on deck.

Q. How would you get under way?

A. Heave short, loose sails, hoist the main-sail, trice the tack up, and overhaul the main-sheet. Heave the anchor up, when off the ground run the fore-sail up, with sheet to windward, helm down, boom well in; as soon as the anchor is up, let draw fore-sheet, shift the helm, haul in the main-sheet, set the jib, and down-tack of the main-sail.

Q. How would you tack?

A. Ease down helm; as soon as she comes head to wind slack off jib-sheet. As soon as the jib fills on the other tack, let draw the fore-sheet and haul aft jib-sheet, and trim sail.

Q. How would you wear round?

A. Up with the helm, trice up the tack, and ease down the peak and throat. When before the wind, shift over the main-boom, get the head-sheets over, and as she rounds to, down tack of main-sail.

Q. You are running before the wind, and wish to gybe, what precautions should you take?

A. Gybing in a fore-and-aft vessel requires great care, otherwise it is dangerous; the chances are that the main-boom may be sprung, or the sail split, when the boom is brought up with a jerk, after going over. In a light breeze and smooth water it may be done with a whole main-sail set, but in a strong breeze in a sea-way it requires preparation and care. The first thing is to reduce the power of the main-sail; this is readily done by tricing up the tack of the main-sail, first topping the boom well up, and easing down the peak and throat; quarter the wind (if running with it aft) and haul in the main-sheet, unhook the guy before putting the helm up, and gather in

quickly as much of the sheet as possible, while the vessel is paying off and the boom is going over. When you have brought the wind on the other quarter, hook on your guy, slack off the main sheet, trim and make sail.

Q. Suppose your mast-head broke off just above the eyes of the rigging. and carried away your peak-halliards and its blocks, how would you set your main-sail?

A. With three reefs, and hoist the peak of the gaff with the lee-boom topping-lift, or unbend the sail from the gaff, take an Irishman's reef in (that is, tie up) head of the sail, and hoist up with the throat-halliards.

Q. Your bowsprit is carried away near the gammon-iron?

A. Luff-up and heave-to by putting down the helm, and haul fore-sheet to windward. Trice up the tack of the main-sail, top the boom well up, and haul in the main-sheet; parbuckle bowsprit alongside to leeward, that is, get a rope round each end of the broken spar, with one part made fast in-board, and hauling on them roll the spar in-board; secure the jib and gear, take the shroud-iron off the end, unreeve the inner stump of the bowsprit from the bitts. Reeve the long or outer end of the bowsprit through the bitts and gammon-iron, put on the traveller and shroud-iron, sheepshank shrouds and bobstay, run out the bowsprit, lash the heel to the bitts, keeping the sheave in the outer end fair up and down. Set up shrouds, bobstay and top-mast stay. Set a small jib, put the helm up, trim and make sail.

Q. Fore-sail carried away. What would you do?

A. Put the helm down. Trice up the tack and ease down throat- and peak-halliards; down foresail, hook the halliards on to the stem-head, haul them taut: send a hand aloft to place a strap round the mast-head just over the collar of the forestay, hook on a good double block, and reeve luff-tackle of sufficient length to reach to the stem-head; hook on, sway away until the strain is taken off the fore-halliard, belay securely, and jog on to the nearest port.

Q. Your bowsprit-shroud is carried away. What would you do?

A. In a strong breeze put the helm down and keep her easy to the wind. Ease in the jib half way, hoist it well up, and trim the sheet after securing the shroud with a shroud-knot, if rope; if chain, reef knot it, stop the ends, set up the gear, trim and make sail.

Q. How would you anchor on a wind?

A. Trice up the tack of the main-sail, take in the jib, slack and trice up the bobstay, put the helm down, when she comes up head to wind meet her with the helm, let the fore-sail run down, keep her head to wind until she loses headway, then let go the anchor, and pay out chain. When she is brought up, lower the main-sail, and furl sail.

Q. How would you anchor when running?

A. Haul the head-sails down, slack and trice up bobstay, trice up the tack of the main-sail and drop throat and peak, put the helm down, haul in the main-sheet amidships; when she comes head to wind, keep her so with the helm until she loses headway. Let go the anchor, pay out chain, lower the main-sail, and furl sail.

Q. You are on a wind; heave to so as to allow a boat to come up alongside—smooth water, light winds.

A. Trice tack of main-sail up, haul in main-sheet, and lay both jib and fore-sheet a-weather.

Q. Suppose you were in a strong breeze?

A. Ease off jib-sheet, haul fore-sheet a-weather, and stand by with a line for the boat.

Q. You are close-hauled on port tack, and a man falls overboard, what do you do?

A. Throw the *yacht in the wind*; throw overboard a life-buoy, grating, oars, or

anything that is at hand. By this time the yacht will be on the other tack, and standing toward the man.

Q. You are running in a strong breeze, when a man falls overboard?

A. Haul in main-sheet, up main-tack, round-to, and get the boat in the water.

Q. You spoke just now of a shroud-knot. How is it made?

A. It is generally used to repair a broken or stranded shroud, and is made by taking the two severed ends, unlaying them the same as for a short splice. Place them together closely, take the outside strand of the lower part, and pass it round the upper part in a loop; take the next lower strand, pass it under and up through the bight of the first-named strand; then take the end of the next lower strand, pass it round the end of the first strand, outside of the second strand, and up through the bight of the first strand, draw hand-taut, and do the same with the other part. Draw the strands taut as possible, marl and serve the ends of the strands on each side, and set up your shroud again.

Q. Do the above manœuvres apply to a yawl as well as a cutter?

A. Yes, with two or three exceptions. For instance, in a yawl, when gybing or going about, the mizzen-stays (when carried) have to be attended to; lee one slacked off; and weather one hauled taut whilst in stays. The mizzen-sheet works itself, except when requiring to be eased off or hauled in. In the yawl, the mizzen will be found of great service in keeping the vessel's head to the sea whilst getting the storm try-sail on her; also a yawl can be got under way with her mizzen and jib alone.

Schooner-Rig.

Q. What is a fore-and-aft schooner-rig?

A. That of a schooner without a square top-sail, in place of which she sets a fore gaff top-sail.

Q. What is a top-sail schooner-rig?

A. A fore-and-aft main-sail and gaff top-sail upon the main-mast; gaff fore-sail and stay-sail set on the fore-stay and one or two jibs, square top-sail and top-gallant sail on the foremast, and with a standing bowsprit.

Q. Where is the fore-stay usually set up?

A. Generally to a bull's-eye in an iron band on the bowsprit, just inside or outside the stem, unless the vessel has a running bowsprit, when it is fitted to the stem-head.

Q. How is the main-mast stayed?

A. With a triatic-stay. That is, a stout stay from one lower mast-head to the other.

Q. Are any other stays used for this mast?

A. Yes, in large schooners a double stay, set up with a runner and tackle to eye-bolts near the water-ways, one on each side, about the after part of the fore-rigging. In harbor, both are set up. When under way, the lee one is let go, to be clear of the fore-sail.

Q. How are the peak-halliards of the main-sail rove?

A. Through three single blocks on the mast-head, two on the gaff. The hauling part on one side on deck, and the standing part on the other, the latter being fitted with a gun-tackle purchase.

Q. How are they used when setting the main-sail?

A. Hoisted taut with the hauling, and then set up with the standing part.

Q. How is the outer end, or clew of main-sail, secured?

A. Generally shackled on to a traveller, with about three feet drift to slack up when the sail shrinks with wet.

Q. How are the tack tricing-lines fitted?

A. With a gun-tackle purchase; a single block on the tack of the sail, and one underneath the jaws of the gaff; from this the hauling part leads on deck.

Q. How are boom topping-lifts usually fitted?

A. In small vessels from the boom-end to the main-mast head leading on deck. Single block on boom end, the standing part and single block at mast-head. In large vessels they are fitted one on each side: they are hooked on to the main-boom, half way between the sheet-block and the reef-chocks. They then lead through blocks on the cheek of the mast on to the deck, where they are set up with a runner and tackle.

Q. Where is the reef-tackle of the main-sail usually kept?

A. It is hooked on to eye-bolts under the main-boom.

Q. How are the reef-pennants fitted?

A. One end is a Matthew Walker, or double wall-knot, and it is then rove through an eye-bolt or bee-block on one side of the boom, then through the cringle on the after leech of the sail, and down through a chock or bee-block on the other side of the boom. This end is made fast to the tackle when reefing.

Q. Where is the storm try-sail gaff usually carried?

A. On the top of the main-boom, in chocks or beds in large vessels.

Q. Proceed to get under way, and cast to starboard.

A. Heave short. Set fore-sail and main-sail, taking care to lead the gaff between the topping-lifts. Trice the tacks up. Loose the head-sails, and then heave up the anchor. When the anchor is off the ground, run the jib up (starboard the helm). When the anchor is up, cast loose your square top-sail, if you have one; down tacks and make sail, shifting the helm as soon as the top-sail is filled.

Q. How would you put the vessel about, or tack?

A. See the ropes clear fore and aft. Main-stays (when fitted) clear: the lee one ready for setting up when she comes head to wind, and the other for letting go. Put the helm down, haul in the main-sheet, ease off jib-sheet. When head to wind, haul over head-sheets, keeping the fore stay-sail to windward, to help to box off. As soon as she is sufficiently off to fill the square top-sail, let draw the fore stay-sail, and trim sails. Shift gaff top-sail tack and main-tack tackle over to windward.

Q. How would you wear the vessel round?

A. Trip up or haul down the gaff top-sail, haul up the tack of the main-sail. Ease up the peak and throat-halliards if needful, ease off the main-sheet, and put the helm up. As she pays off, round in the weather-braces, and haul in the slack of main-sheet. As she comes round, shift the main-boom over, brace up the yards, hoist the peak of main-sail, down main-tack, trim sails, and set gaff top-sail.

Q. Suppose your weather-boom topping-lift broke while you were close-hauled, what would you do?

A. Haul taut the lee one until the other was spliced.

Q. Suppose the lee one was unhooked to prevent chafe?

A. In that case I would ease off the gaff top-sail sheet, also the throat and peak-halliards; to lower the boom on to the rail, secure it there till the lee one was shifted over to windward, hook it on, and trim main-sail. Splice the broken one, and send it aloft for a lee one.

Q. Being on a wind, proceed to trim sail so as to keep the wind nearly dead aft, say about a point on the quarter.

A. Hook on the guy-pennant to the main-boom, and pass it outside of the lee main-rigging, bring the end inboard to the lee-waist, hook on the guy-tackle from the windlass-bitts; trice up the *tack of the main*-sail; put the helm up, check the yards, ease

off main-sheet, and take in the slack of boom guy-tackle; haul flying-jib down, and ease away fore-sail and fore stay-sail sheets.

Q. How would you set the square-sail?

A. Hook on the yard-whips to the head-cringles, and the fore stay-sail halliards to the middle of the head; hoist up and trim, having a down-haul to each halliard.

Q. Describe how yard-arm whips are fitted.

A. The standing part of whip and a single block on the yard-arm. a hook-block on the sail. The whip leads from the yard-arm to a block on the yard-truss, or to the lower mast-head. From thence on deck.

Q. How would you take in the square-sail, supposing it was blowing a strong and increasing breeze?

A. Slack away the yard-arm whips, hauling in on the down-haul; when they are down as low as possible, slack away the midship-halliards, and gather in the sail. (Tack and sheet to be kept fast till the sail is down.)

Q. What is to prevent the head of the sail blowing away from you when you let go the midship-halliard?

A. The lizard, which is bent on to the middle of the head of sail before hoisting it up.

Q. Describe this.

A. A thimble with a rope-tail; this travels on the top-sail sheet in light winds, or on a wire-rope jumper from the mast-head to the deck. A down-haul is usually bent on to it.

Q. How would you reef the square top-sail?

A. Lower the yard down. Trim with the braces to keep the sail on the lift. Haul out reef-tackles, haul taut bunt-lines and clew-lines. Send men aloft to reef.

Q. With a reef in and the sail set, how would you shake it out?

A. Lower the yard down, haul the braces taut, haul out the reef-tackles, let go the reef-points, ease off the earings; overhaul the gear, especially your reef-tackles. Before coming down from aloft, hoist the yard up, and trim with the braces.

Q. How would you reef the main-sail?

A. Haul the boom well in, hook the tackle on to the reef-pennant. Lower the throat and peak-halliards sufficiently to take in the reef, haul on the reef-tackle till the cringle on the after-leech of the sail is down on the boom. Pass the tack-earing. Tie the reef-points. Hoist up throat and peak, and trim sail. Take in the slack of the vangs (if any) and peak-line.

Q. You are running with the wind on the port-quarter, moderate wind, smooth water. The man at the helm lets her run off so as to bring the wind on the starboard quarter; what would you do?

A. Hard-a-starboard the helm, ease down the throat and peak-halliards, and trice the tack of the main-sail up. When she has come back, hoist up the peak and down with the tack.

Q. Suppose this happened in a strong breeze, what danger would you apprehend supposing your guy-pennant had broken?

A. That the bight of the boom-sheet, as the boom was going over might sweep everything off the deck that it came in contact with. The sudden jerk also might spring the boom, carry away the main-sheet, or split the sail.

Q. What is meant by the term goose-wing?

A. Running with the gaff fore-sail guyed out on one side, and the main-sail on the other.

Q. Where do the guys lead?

A. Main one between the fore and main-rigging to the windlass-bitts, and the fore

one through a block on the bowsprit-end. Sometimes the fore-guy is led to the cat-heads.

Q. Suppose you were running in a gale with the wind dead aft, what canvas would you carry?

A. Close-reefed square-topsail; having the storm try-sail and fore stay-sail reefed and ready for setting when required.

Q. Your top-sail blows away, and the vessel will not keep ahead of the sea. What would you do?

A. Down helm and heave-to under the storm try-sail and storm fore stay-sail with sheet-a-weather.

Q. On what occasion would you set your storm try-sail in preference to a close-reefed main-sail?

A. When it was likely that I should be compelled to heave-to, or when the sea was getting heavy.

Q. Why in the latter case?

A. To take the weight of the main-boom off the vessel. I would secure main-boom in the crutch or on the rail before setting the storm try-sail.

Q. Describe a storm try-sail.

A. It is made of No. 1 canvas, either with a jib-head, or with three cloths in the head; if the latter, it is bent on to a short gaff, and hoisted up as far as the throat-halliards of the main-gaff will take it. The clew is hauled aft by a luff-tackle on deck. The luff of the sail is either laced round the mast, or fitted with rope-beckets, on which travelling-trucks are rove.

Q. Why is it made to hoist so high?

A. To catch the wind in a heavy sea.

Q. How would you gybe it if you were taken aback?

A. By the weather-tackle, which is hooked on over the main-boom and gaff. The peak-halliards of the latter, and the topping-lifts of the former being unhooked and taken into the mast, to be out of the way of the storm try-sail.

Q. You are in a gale, no storm try-sail on board. What canvas would you heave-to under?

A. A balance-reefed main-sail, or a jib abaft the mast.

Q. Describe a balance-reef.

A. It is used after the third or close-reef has been taken in. The eyelet-holes for the reef-points extend from the close-reef cringle on the after-leech up to the throat-earing in small vessels, but in large vessels from the cringle in the after-leech to about two or three feet below the throat-earing, and on to the luff of the sail, where a cringle is worked in to hook on the tack-tackle.

Q. How would you take in a balance-reef, close-reef being in?

A. Ease the peak-halliards to take the strain off the after leech; lower the jaws of the gaff down by the throat-halliards. Hook on the tack-tackle to the cringle on the luff of the sail; reeve the points, tie them; set up throat- and peak-halliards; shorten vangs, if any, and peak-line.

Q. Under sail on a wind with a jump of a sea, what precautions would you take to prevent the main-boom from jerking up and down?

A. A guy for this purpose is usually put on the boom, just inside of the main-sheet, and led to the main-rigging. It is usually called a lazy-guy.

Q. Describe it, and how it is put on.

A. A stout rope (about three fathoms) with a thimble in one end; this is clove-hitched round the boom, leaving the thimble about a foot below the boom. The bight

of the rope is then put under a cleat or chock, and the end rove through the thimble and belayed. It can be let go and cleared in a moment.

Q. You lose your bowsprit; it breaks off outside of gammoning; you are on a wind, what would you do?

A. Shorten sail, clear away the wreck, and secure the head-stays to the stump of the bowsprit.

Q. You are running in the Atlantic to the eastward, under a three-reefed main-sail, close-reefed fore stay-sail, and double-reefed fore-sail. The wind at southwest, with heavy sea and rain. Your fore-mast carries away about six feet above the deck, taking the fore stay-sail and fore-sail with it. The triatic-stay had broken the head of the main-mast off above the eyes of the rigging when the fore-mast fell, and also broke the peak-halliards of the main-sail, which caused the peak of the main-gaff to drop. What would you do?

A. Port the helm, round-to on the starboard tack, and clear away the wreck.

Q. Why on the starboard tack?

A. Because it would prevent gybing, and as the wind might draw round to westward, the vessel would come up and head the sea.

Q. What would you do next?

A. Balance-reef the main-sail, and lie to till the weather moderated, attending to the pumps during the interval.

Q. How would you hoist the peak of your main-gaff with a balance reef in, the mast-head and peak-halliards having carried away above the rigging?

A. Hoist the peak of the gaff up with the lee-boom topping-lift; or unbend the sail from the gaff, take an Irish reef in it, and hoist it by the throat-halliards.

Q. The fore-mast being gone, she will not lie to with a balance-reefed main sail. What would you do?

A. Lower it down, and try her under a small jib abaft the mast.

Q. What would you do when it moderated?

A. Take the main-boom and rig it for a fore-mast, and after it was secured to the stump of the old mast, I would take the storm main try-sail and gaff, and rig and set it as a fore try-sail.

Q. How would you set your main-sail without a boom?

A. Treble-reefed, with a luff-tackle for a sheet.

Q. How would you proceed to ship your main-boom as a fore-mast?

A. Unship the boom from main-mast; get the jaws of the boom against the stump of fore-mast on the deck. Lift the after end of the boom, with one of the boom topping-lifts, high enough for a tackle from the bowsprit to bowse it perpendicularly, having a guy on each side to keep the head of the boom amidships. I would clove-hitch a warp over the upper end of the boom for two stays before hoisting the boom up. For shrouds I would use the two main-boom topping-lifts, one on each side, which are fitted with a runner and tackle. When perpendicular, lash and wedge the heel of the boom to the stump of fore-mast.

Q. How would you moor?

A. Bring up with best bower anchor, slack away chain (say about sixty fathoms), and if the vessel would not drift to a position suitable for letting go the second anchor, send out a kedge anchor with a warp, and warp her to it. Let go the second anchor, slack away the chain, heaving in the best bower-chain at the same time, until I had equal lengths out on both cables.

Q. How would you proceed to unmoor?

A. Slack away on the weather-cable, heave up the lee-anchor, cat and fish it; then heave short on the weather cable, ready for getting under way.

Q. What is a lee tide?
A. A tide setting to leeward, and with the wind.
Q. How would you tend a vessel in a tideway?
A. A light vessel to leeward, a loaded vessel to windward.
Q. Suppose you were at anchor in a calm, how would you keep the chain clear of the anchor?
A. By heaving in the cable quite short, without tripping the anchor.
Q. What is meant by tide-rode?
A. Swung round by the tide, and riding head to it at anchor.
Q. What is meant by wind-rode?
A. When swung round by the force of the wind at anchor against the tide.
Q. How would you place a kedge in a boat for carrying out?
A. Stock over the stern flukes in the boat, on a plank or spar for canting overboard.
Q. How would you carry out a bower anchor?
A. The crown under the boat with a slip-rope, and a ring-rope over the stern.
Q. You are on a lee shore, on anchorage ground, she will not stay, and there is no room to wear, how would you get her round?
A. Let go the anchor, or, if time allow, unshackle lee-anchor, bend on a warp from the lee-quarter, let go the anchor when the helm is put down, gather in the slack, and hold on the warp; this will check her round. When round, slip the warp.
Q. How would you construct a raft to rescue a crew?
A. Three spare spars lashed as a triangle, with water-casks lashed inside of the triangle, and small, spare spars lashed on top.
Q. Your rudder is carried away; what do you do?
A. If running, lower down the fore-sail, get main sheet in, and fore stay-sail sheet to windward. Get three spars and make a triangle; secure a sail over them; bend on a spar; and sling some pieces of iron to the lower spar; bend on a stout warp to the spar; heave over to windward, veer over the hawser, and the vessel will lie-to comfortably while you are rigging a jury-rudder.
Q. You have no time to do this; you are on a lee shore?
A. Get a square top-sail yard; nail a couple of stout boards to one end at right angles to each other; pass it out under the taffrail; lash it amidships; get a luff-tackle on the inboard end; and you will find she will steer, unless a very unhandy vessel.
Q. You have no time for this even?
A. Then let go both anchors, and cut away the masts, if she will not ride to it without.
Q. What is a spinnaker?
A. A lofty triangular-shaped sail made of light canvas, used in modern racing-yachts instead of a square-sail for running before the wind. The foot of it is extended by means of a long spar called the spinnaker-boom, which works with a goose-neck on the fore-side of the mast.
Q. How do you set and take in a spinnaker?
A. Get the inner end of the boom over the taffrail on the side opposite to that on which you are carrying the main-boom; light it along until the outer end is far enough aft to clear the head-sheets, then launch forward; hook on the topping-lift; bend on a couple of whips purchased to the outer end, lead one forward and the other aft; hoist away on the topping-lift until it takes the weight of the boom; shove it forward until the goose-neck can be shipped in its place on the mast. Bend on the halliards to the head of the sail, and the outer clew to the out-haul on the boom, taking care that it is on the *fore side of the topping-lift.* Hoist away on the halliards, and at the

same time haul out the clew; when it is chock up to the topmast head, the clew close out and the inner clew fast, slack down your topping-lift until the boom is just clear of the rail, and trim with the after-guy. In large vessels it is usual to have another guy from the outer end to the side of the vessel, to keep the boom from rising when the sail is distended by the pressure of the wind. In taking in a spinnaker, top the boom well up, ease in the out-haul, and slack away the halliards at the same time, and gather in the sail as it comes down. Ease away the after-guy until the boom is fore and aft; unship the goose-neck, and stow it along the deck; or the boom may be hoisted up with the topping-lift until it is parallel with the mast.

Q. How would you set it as a jib?

A. Lash a small tail-block on the bowsprit outside the shroud-iron; reeve a rope through it; bend it on to the outer clew of your spinnaker, and haul chock out; belay and hoist away on the halliards; use the balloon-jib sheets for spinnaker-sheets.

Q. You have not said anything about the preventer back-stays. What are they?

A. Temporary stays leading in yachts from the top-mast head to the quarters. They are used when the jib top-sail or spinnaker is set.

Q. You have spoken several times about "heaving-to." Now, you are running in a strong gale with heavy sea, and it is necessary to "heave-to" to shorten sail, how would you do it so as not to run the risk of having the decks swept?

A. Batten down the hatches, get everybody aft to the main-sheet, watch for a smooth sea, and, as the yacht begins to descend, ease down the helm, and as the vessel comes up to the wind get in the main-sheet foot by foot; haul fore-sheet to windward, lash the helm a-lee, and proceed to reduce your canvas.

Q. Suppose you are beating through a crowded channel, with a very light breeze and strong tide, and find you are drifting foul of other vessels; what would you do?

A. If the tide was adverse, bring up. If the tide was favorable, I would get the anchor or kedge over to leeward with plenty of chain, bend on a stout hawser to the chain within a couple of feet of the anchor, and lead it aft to the quarter. Put the helm down and let her come-to; when she begins to lose way, let go the anchor to leeward and haul on the hawser; when she is fairly round, slip your cable and haul in the anchor over the stern.

Q. You are trying to claw off a leeshore in a gale under storm-jib and three-reefed main-sail, and your vessel persists in running off her helm in the squalls; what would you do?

A. Get everything below that was at all weighty into the fore-peak, and sail her with the head-sheets very flat.

Section 8.

PRACTICAL NOTES ON STEAM-ENGINEERING.

STEAM: TABLES, FORMULÆ, ETC.

STEAM-JACKETS.

STRENGTH OF ENGINES, HORSE-POWER, ETC.

GETTING UNDER WAY. UNDER WAY.

COMING TO ANCHOR.

CAPACITY OF COAL-BUNKERS.

PADDLE-WHEELS. SCREW-PROPELLER.

BOILERS, ATTACHMENTS, ETC.

BOILER-PLATE.

VALVES, SLIDE, ETC. SEA-VALVES.

STEERING-APPARATUS. DISTILLED WATER.

KINDS AND TYPES OF ENGINES. PUMPS.

PRACTICAL NOTES ON STEAM-ENGINEERING,

BY GEORGE W. BAIRD,

PASSED ASSISTANT ENGINEER, U.S.N.

STEAM.

BY saturated steam we understand the steam to be just sufficiently heated to continue in the form of vapor. Applying heat to saturated steam converts the small particles of water held in suspension into steam, and, when this process is complete, a further application of heat causes superheating, provided the steam is not confined so as to increase its pressure; but, if saturated steam be cooled, a part of it will condense.

There are two distinct phases in the conversion of water into steam, and to readily comprehend these we will take them in their order. A thermal unit is the amount of heat required to raise one pound of water one degree at its maximum density (39° F.), and this is practically constant for any calculation with the steam-engine, though it increases slightly with temperature. Now, if heat be applied to a pound of water at the freezing-point (32° F.), and continued until the temperature reaches the boiling-point (212° F.), there will be consumed ($212-32=$) 180 thermal units. The water absorbing heat, evaporation now commences, and if the pressure be not increased above the atmosphere, the water will be entirely evaporated without indicating any increase of temperature. But to evaporate this pound of water, after raising it to the boiling-point, there will be consumed 966 thermal units. This heat is expended in overcoming the resistance of the particles of the water to the repulsion incident to the change into vapor, and also to the work of expansion against the resistance of the atmosphere in which it is formed, so that the total expenditure of heat in changing a pound of water at 32° F. into steam at 212° F. is ($180+966=$)1,146 units. The quantity 966 is called the latent heat of vaporization, and is determined by subtracting the sensible from the total heat.

Properties of Saturated Steam.

Pressure in lbs. per square inch above zero.	Temperature.	Latent heat.	Total heat.	Relative volume of steam and water.
1	102.0	1043.0	1145.1	20,890
5	162.4	1001.0	1163.3	4,672
10	193.3	979.6	1172.9	2,429
14.7	212.0	966.6	1178.6	1,703
15	213.1	965.9	1178.9	1,699
20	228.0	955.5	1183.5	1,280
25	240.2	947.0	1187.2	1,042
30	250.4	939.9	1190.3	881
35	259.3	933.7	1193.0	764
40	267.3	928.1	1195.4	676
45	274.4	923.2	1197.6	608
50	281.0	918.6	1199.6	552
55	287.1	914.4	1201.5	506
60	292.7	910.5	1203.2	467
65	298.0	906.8	1204.8	434
70	302.9	903.4	1206.3	406
75	307.5	900.3	1207.8	381
80	312.0	897.1	1209.1	359
85	316.1	894.3	1210.4	430
90	320.2	891.4	1211.6	323
95	324.1	888.7	1212.8	307
100	327.8	886.1	1213.9	293

Superheated steam follows the law of expanding gases, while saturated steam—even if dry—does not. Many formulæ have been offered for determining the relation between temperature and pressure, but none of them are exact.

Sothern gave $P=\left(\frac{t+51.3}{135.767}\right)^{5.15}+0.1$, in which P is the pressure and t the temperature.

Rankine's formula is almost exact, and is as follows:

$$log.\ P=A-\frac{B}{\tau},\ \frac{C}{\tau^2},\ \text{and}\ \frac{1}{\tau}=\sqrt{\frac{A-log.\ P}{C}+\frac{B^2}{4C^2}}-\frac{B}{2C},$$

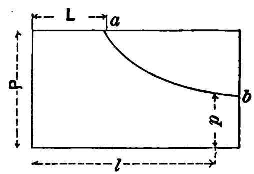
in which P=pressure, t=absolute temperature, and A, B and C are constants. $A=8.259$; *log.* $B=3.436$; *log.* $C=5.599$; $\frac{B}{2C}=0.00344$; $\frac{B^2}{4C^2}=0.00001184$. When great accuracy is not required, the writer has employed the formula :

$$T=\left(\sqrt[6]{P}-0.53\right)201,$$

where T=temperature and P=pressure.

The specific heat of steam under constant pressure is 0.48, and under constant volume is 0.346.

Mariotte's law of expanding gases held that the pressure varied inversely as the spaces occupied ; *i.e.*, that if a gas be forced into a cylinder until the piston moved half its stroke, the supply of gas then being cut off and the motion of the piston continued to the end of the stroke, the terminal pressure would be just one-half the pressure at the point of cutting off. This law was applied to the steam-engine until a recent period, when its fallacy was proved by Chief Engineer Isherwood.* It is still employed to demonstrate the pressures due to expansion, and is approximately correct where superheated steam and the steam-jacket are employed. From this law it is easy to calculate the pressure of steam at any point of the stroke of the piston, if the pressure at the point of cut-off, and the distance travelled by the piston when the steam is cut off, be known. The pressure is always reckoned from zero (*i.e.*, perfect vacuum) and the lengths are fractions of the stroke.



* "Until a comparatively recent period, steam was regarded by engineers and treated by philosophers as a permanent gas, whereas it is really a most unstable fluid. . . . . It is not too much to say that Mr. Isherwood, of the U. S. Navy, in his masterly preface to the second volume of Experimental Researches in Steam Engineering, was the first who had the courage to dispute the soundness of this vicious theory."—London Engineer, January 4, 1878.

Let L = the length of the stroke completed when the steam is cut off, and P = the pressure at the point of cutting off, then the pressure p at any point of the stroke l from the commencement will be

$$p=\frac{PL}{l}.$$

From Mariotte's law, the curve, $a\,b$, of expansion is a hyperbola, from which $p=\frac{PL}{l}$ may be deduced.

Example.—An engine has a stroke of piston of 105 inches, cuts off at 51 inches from the commencement of the stroke, and the pressure at the point of cut-off is 30 pounds above the atmosphere; required the pressure at the end of the stroke. We have $p=\frac{PL}{l}=\frac{(30+14.7)\,51}{105}=21.7$ pounds above zero, or $(21.7-14.7=)$ 7 pounds above the atmosphere.

Considerable fuel is saved by cutting-off the steam before the stroke is completed, thus allowing the expansive force of the steam to do useful work. According to Mariotte's law, the greatest economy was realized with the shortest cut-off; but carefully conducted experiments proved it to be about three expansions when twenty-five pounds boiler-pressure was employed in an unjacketed cylinder of a condensing engine, and about one and one-half expansions in a non-condensing engine. With fifty pounds boiler-pressure these figures become five and two and one-half respectively, and at higher pressures the economic point of cut-off is still less.

One of the principal causes for the departure of the true law from that of Mariotte, is the chilling of the cylinder when the exhaust-valve opens and places it in communication with the condenser; for when the live-steam comes in contact with the cylinder on the next stroke, there is a condensation upon its surface, and when the steam is cut-off, and the pressure falls in the cylinder, there is a re-evaporation of that water, which absorbs a great quantity of heat and destroys, consequently, much pressure. In order to obviate this cylinder-condensation, which becomes a serious matter in large engines, the steam-jacket is used. This is essentially enveloping the cylinder in steam at the boiler-pressure, and is affected by placing a cylindrical

lining in the cylinder, with an annular space for the steam ; by casting the cylinder-heads hollow, and by filling the annular space and hollow heads with boiler-steam.

By using the steam-jacket, the economic point of cutting-off is shortened somewhat, but in order to preserve the mean pressure it is necessary to increase the boiler-pressure. When high boiler-pressure and short cut-off are used, the piston is moved as if by blows, and the torsion upon the shaft is intermittent, but by compounding the engine, the torsion is more uniform. The strength of the material in an engine is calculated for the maximum pressure, and this occurs at the commencement of the stroke. Taking a compound and a single-expansion engine, having equal volumes of cylinder, velocities of piston, carrying the same initial pressures, etc., and expanding through the same range, it will be found that they will develop the same indicated power in the cylinders, but it will be found that the initial load upon the pistons of the single-expansion engine will be greater than that of the other, and that its working parts, frames, etc., must be built correspondingly heavier. From the more uniform pressure and torsion of the compound-engine, it follows that it will be a smoother-working machine, and it will probably be found that, from the same cause, there will be a greater net power applied to the propulsion of the ship. The advantage of the compound over the single-expansion engine is mechanical

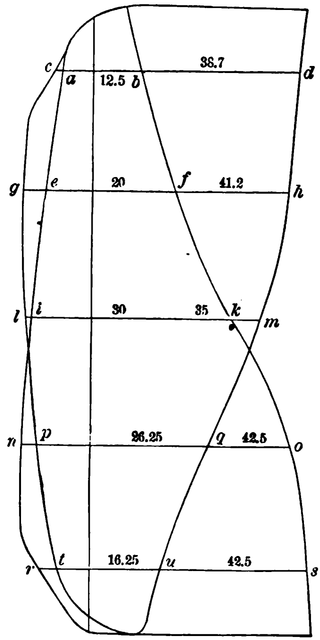


FIG. 1.

and not physical, but the advantage of the system is sufficient to warrant its use for large powers.

The horse-power of an engine is calculated from indicator-diagrams. The length of the indicator-card refers to the stroke of the piston, and the perpendicular lines indicate the pressures. A horse-power is reckoned to be 33,000 pounds raised one foot high in one minute, and the horse-power of an engine is the mean unbalanced pressure per square inch upon its piston, multiplied by the area of the piston in square inches, multiplied by the velocity of the piston in feet per minute, divided by 33,000.

Let A=area of piston, p=mean pressure, v=velocity of piston, then the horse-power will be $\frac{A\,p\,v}{33{,}000}$.

The velocity of the piston in feet per minute is the length of the stroke in feet, multiplied by the number of strokes per minute.

Example.—One cylinder of the U. S. Fish Commission steamer Fish Hawk, is twenty-two inches in diameter, and the stroke of piston is 2.25 feet; at 103 revolutions per minute the velocity of piston was $(103 \times 2 \times 2.25) = 463.5$ feet per minute. Lay off, on the double indicator-card, Fig. 1, the ordinates $a\,b$, $c\,d$, $e\,f$, $g\,h$, and so on, and measure, with the scale of the indicator, the lengths of those ordinates. The measurements are as follows: 12.5, 38.7, 20, 41.2, 30, 35, 26.25, 42.5, 16.25, and 42.5, the sum of which is 304.9, and this sum, divided by the number of ordinates on both cards (10), is 30.49 pounds per square inch. Then the power developed by that engine is

$$HP = \frac{A\,v\,p}{33{,}000} = \frac{380.13 \times 30.49 \times 463.5}{33{,}000} = 162$$

GETTING UNDER WAY.

SEE that all the man and hand-hole plates are on the boilers and are screwed up; run or pump the water into the boiler to its proper level before lighting the fires. Spread a layer of coal over the back half of the grates, and kindle a wood-fire on the front half, closing the ash-pit doors and leaving the furnace-doors partly open; as soon as the fire begins to burn briskly, the ash-pit door is to be removed, and the furnace-door closed, and when the coal in the back of the furnace ignites, a fresh supply may be added, but care

must be taken to put on very little at a time or the fire will be put out. A careful engineer will always open his stop-valves and his drain-cocks before steam is formed, and also see that the safety-valves are in working order. He will see that the boiler-blows are closed, and that his donkey-pumps are arranged for working by steam (for many are arranged to disconnect and work by hand), and that the sea-valves are open for admitting water to the pumps; that the out-board delivery-valves are opened and that the oil-cups are supplied with oil, and the wicks are prepared. It is better not to urge the fires at first, but let steam form gradually, and as soon as pressure begins to manifest itself, the jacket-valves should be opened and the cylinders warmed. If the circulating-pumps are independent, they should be started as soon as there is enough pressure, so that should any adjusting be found necessary, or any leaks appear, there will be time to remedy them. Steam should now be turned on the anchor-engine, and its cylinder-cocks opened and blown through, and the chain-holder keyed on, ready for hoisting the anchor. When steam has reached a sufficient pressure, the main-engines should be blown through and revolved, to ascertain if they are all right, and when the pressure reaches the working limit, the steam should be blown directly into the condenser if the circulating-pumps are independent; but should the circulating-pump be connected to the main-engine, it will be necessary to open the furnace-doors, feed cold water into the boilers, or else blow off the steam through the safety-valves, either of which is objectionable. The circulating-pumps should always be built independent. Before reporting the engine ready for sea, the engineer should see that there has been nothing left in the way of the working parts, and that all the spare machinery, tools and stores in the engine-room are properly secured in place. A marine-engine should always be started slowly, on account of the water in the pipes and that liable to be foamed over from the boilers; but in working to signals, when the boilers are making steam freely, and when the cylinders and pipes are hot, the engine may be handled more quickly. When the engine is in motion and it is desired to reverse, the signal should be first to stop, and then to reverse. The oiler should not start the wicks in the oil-cups to feeding until the engine is about to be started.

UNDER WAY.

WHEN the vessel is under way, the running of the engine should be regulated as circumstances demand. There are two problems to meet, and the elements of these problems are varying. The first is speed, and the second is economy. It is a waste of fuel, and it is dangerous to the ship and machinery, to urge her against a gale of wind, and it is a penny-wise policy to reduce the speed to a minimum in good weather, in order to "save coal." The economy of coal is measured in more than one way. The efficiency of a marine engine is measured by the weight of coal consumed per horse-power per hour, while the commercial economy is sometimes measured by the coal consumed per mile. But when the interest on the capital invested in the vessel, together with the running expenses, be considered, and this sum divided by the receipts, it will be found that a high rate of speed—a speed that calls for considerably more coal per mile—yields a greater net profit than a lower speed. If the weather were always the one thing, and if we could keep the condition of the machinery and the hull of a ship constant, it would be an easy matter to calculate the most economic speed, but these are the varying factors that must be met by judgment. In war-vessels it is the practice to make long voyages under sail, that coal may be saved. Under some circumstances this is correct, for example, when the wind is free and sufficiently strong to give the vessel a reasonably good speed; but the policy of making a voyage under sail of forty-two days, the vessel being close-hauled on one tack for thirty-seven days (the men getting no exercise in seamanship), when the same voyage could be made in twenty days under steam, is not a wise policy.

In peace times the use of a ship-of-war is when she is in port, where, by her presence, and by the intercourse of the officials, a good international feeling is preserved, and whereby our commercial relations are strengthened and extended. The vessel to which I refer was kept in commission at a daily cost of about \$1,000, so that the expense of the forty-two days' passage was about \$42,000. Had the voyage been made under steam, occupying twenty days, using coal costing \$20 per ton, and the consumption thirty tons per day, the cost of the voyage would have been $(30 \times 20 \times 20) + 20 \times 1000 =$ *\$32,000*, a saving of (\$42,000—32,000)=\$10,000 in money and twenty-

two days in time. This vessel is an old-fashioned ship; the saving by steaming in the new vessels, with compound engines, would be much greater.

When the rate of speed or the amount of power to be used is fixed upon, the cut-off valves of the engine should be so adjusted as to keep the boiler-pressure nearly up to its working limit, and the speed of the circulating pumps so regulated as to obtain a good vacuum and proper temperature of feed-water. These quantities are not exactly the same for any two condensers, and they sometimes vary considerably. It must be remembered that water boils at a lower temperature in a vacuum than under pressure, and that there is a consequent danger of evaporating the water in the air-pump and sending it overboard in the condition of vapor, which loss must be made good by supplying the feed-pump with sea-water. The most economic temperature of the feed-water is about 104 degrees, and, with a correctly-constructed condenser, a vacuum of about 27 inches will be obtained with the feed-water at 104 degrees.

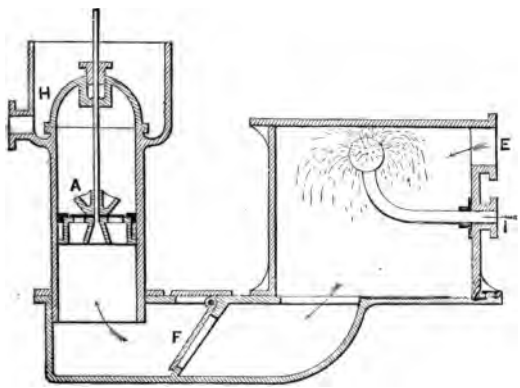


FIG. 2.

Condensers.—Fig. 2 represents a section of the jet-condenser, channel plate, and air-pump, as used on our river boats with the

working-beam engines. The exhaust steam from the cylinder enters the condenser at E, and the injection water enters at I, passing into the top of the condenser and falling to the bottom through the scattering-plate, or rose. In this form of condenser the steam and injection water are mixed, and after condensation the water is pumped overboard by the air-pump A. This form of condenser has been abandoned for sea-going steamers, as the feed-water for the boilers, as drawn from the hot well, H is nearly as salt as the sea. Sea-water not only boils at a higher temperature than fresh water, but deposits an insoluble salt—principally sulphate of lime—upon the heating surfaces of the boiler, and this is a non-conductor of heat.

One thousand grains of sea-water contains:

Fresh water,*	964.74372
Chloride of sodium,	27.05946
Chloride of magnesium,	3.66656
Chloride of potassium,	0.76552
Bromide of magnesium,	0.02929
Sulphate of magnesia,	2.29578
Sulphate of lime,	1.40662
Carbonate of lime,	0.03301

On the application of a high temperature, the synthetic reaction is between the carbonate of lime and the sulphate of magnesium, when they change places, becoming carbonate of magnesium, which is soluble, and sulphate of lime, which is insoluble. The steam from the boiler is from the water alone, leaving the solid contents behind, and it may be readily understood that the larger the percentage of this solid matter passed through the boiler, the greater will be the deposit of the scale. To prevent this as far as possible, the boiler is blown at certain intervals ; but, as the water blown from the boiler has been heated, there is a loss of heat, and consequently of fuel. The solid matter held in the boiler is estimated from the specific gravity of the water, and is measured by a hydrometer.

Sea-water is held to contain $\frac{1}{32}$ of its weight in saline matter, and the hydrometers are graduated on that scale. As the specific gravity of the water changes with its temperature, it is essential to test the

* Encyclopædia Britannica.

density of the water at a given temperature, and the hydrometers have usually three scales, 190, 200, and 210 degrees of temperature. The scale of 200 is mostly used.

The method of testing the water ("taking saturation," as it is commonly called) is by immersing a thermometer in the "salinometer pot," and allowing the water to flow until 200 degrees is reached, and then read the nearest division of the hydrometer at the surface of the water.

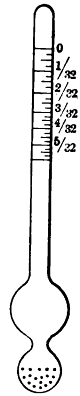


FIG. 3.

The less water blown from the boiler the greater will the density of the water become; and if as much water is blown out as is pumped in by the feed-pump, there will be none vaporized, and no steam supplied to the engine. There is an economic mean, and this has erroneously been decided to be one and three-fourths.* To calculate the loss by blowing-off, let

H=Total heat in the steam.

T=Temperature of the water in the boiler.

t =Temperature of the feed.

E=The amount of vaporization=1.

D=Density of the water in the boiler in 32s.

d =Density of the feed-water in 32s.

* The precipitated scale on the heating surface of the boiler comes principally from the sulphate of lime. If we carry the water at a low density, it is manifest that we must blow a correspondingly large quantity of water from the boiler and supply that amount from the sea. If we carry the water at a high density, we do not blow so much, nor have we to supply so much sea-water as feed. It is manifest, then, that if we blow less, we pass less sea-water through the boiler. It is not disputed that the precipitation takes place at the temperatures we are now using; hence it follows, that by blowing less we accumulate less scale in the boilers. The other solid matter in the boiler does no damage until a density of about $3\frac{1}{2}$ is reached; so we are limited to that density. A few years ago two practice steamers, alike in every respect, left the Naval Academy on a practice cruise. There was a Passed Assistant Engineer of the Navy on each in charge of the machinery, these officers being attached to the Academy as Professors. They agreed to test this theory practically, the one obeying the Navy Regulation, in keeping the water in the boiler at $1\frac{3}{4}$, the other disobeying the regulation, in keeping the water at about $2\frac{1}{2}$. The steamers sailed in company, made the same voyages in company, did exactly the same amount of steaming at the same speed and under the same circumstances, with the exception noted. The result was that the boiler in which the water was carried at $1\frac{3}{4}$ was scaled twice during the practice cruise, while the one in which the water was carried at (or about) $2\frac{1}{2}$ was not scaled at all, and returned to the Academy in better condition, freer from scale than did the other one.

B=The amount blown out$=\dfrac{E\,d}{D-d}$........................(1.)

Then the per cent. of loss by blowing will be

$$\frac{100\times(T-t)}{(H-t)\frac{E}{B}+T-t}\quad\text{.....................(2.)}$$

Example.—Required the per cent. of loss by blowing to keep the water at $1\frac{3}{4}$; with the boiler-pressure at 25.3 pounds per square inch above the atmosphere; with the feed at 104°; and the density of the sea-water at 1.

From the table on page 438, we find the temperature, T, due to (25.3 + 14.7 =) 40 pounds absolute pressure, to be 267.3° F., and the total heat 1195.4° F.

Then from formula (1) we have

$$B=\frac{E\,d}{D-d}=\frac{1\times1}{1.75-1}=1.333.$$

And from formula (2)

$$\frac{100\times T-t}{(H-t)\frac{E}{B}+T-t}=\frac{100\times267.3-100}{1195.4-100\times\frac{1}{1.33}+267.3-100}=16.9\text{ per cent.}$$

As a remedy for this evil, surface-condensers were introduced, but for many years it was doubted whether their disadvantages were not greater than their advantages.

It was found difficult to keep them tight; their cost and weight were greater than the jet, and the boilers always suffered from a singular kind of corrosion, evidently due to the surface-condenser. Forming a thin sheet of scale on the heating surfaces went far to obviate this trouble, but it was hard to keep the scale on. Another means was found in suspending sheets of zinc in the boiler, which metal being electro-negative with reference to iron, was soon destroyed, and the boiler was not injured. The most successful means has been the Selden filter. This is a simple arrangement of filter, having woollen screens and a bed of coke, through which the feed-water passes. It was held by some engineers that the corrosion was

from galvanic action, while others held that it was from the solvent action of the oils used in the steam-cylinders, and emptied thence through the condenser into the boiler.

M. Berthelot succeeded in preparing oil artificially from oleic acid and glycerine, and it was found to be identical with the oleine of olive and other fixed oils. A Mr. Wilson, of an English candle manufactory, obtained stearic and oleic acids, and glycerine, by passing steam through melted fats.

The probability is that the oils at the high temperature are resolved into oleic acid and glycerine; the oleic acid attacking the copper in the (brass) tubes of the condenser, the lining of the air-pump, etc., making oleate of copper. The writer has frequently taken a piece of coke from a Selden filter, broken it in two, and observed the metallic copper in the body of the coke. Surgeon Jerome H. Kidder, of the Navy, made some very interesting analyses on the salt found in a filter at Hecker's Flour Mills, and pronounced it oleate of copper. Injecting a solution of carbonate of sodium into surface-condensers has been attended with good results; this alkali combines with the

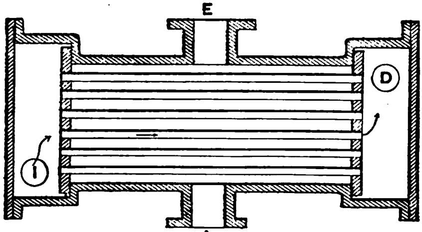


FIG. 4.

grease, making soap, which is arrested in the filter, particularly if the water be the least brackish, as that causes the soap to curdle. Another means is found in lubricating the cylinders with oils manufactured from petroleum—oils which have a composition different from the common fatty or fixed oils of commerce, such as the "Diadem cylinder-oil." With the use of these oils, and using, also, the Selden filter, the life-time of a marine-boiler should be fully fifteen years.

The best form of surface-condenser now used is that in which the tubes lie horizontally, which pass the water through the tubes, and have the ends of the tubes packed.

Fig. 4 is a section of a surface-condenser, the exhaust entering at E, and the air-pump taking the condensed water, vapor, etc., from the bottom at A. The injection-water enters at I, passes through the tubes, and out at D.

Fig. 5 represents Second Assistant (now Chief) Engineer Aston's modification of Sewell's method of packing tubes, which has met

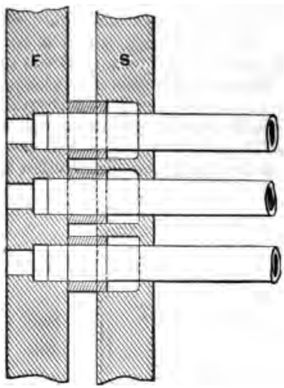


FIG. 5.

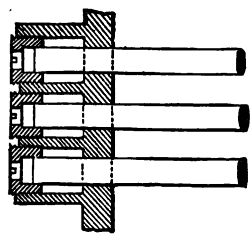


FIG. 6.

with great success in the Navy. There is a stuffing-box in the tube-sheet, S, for every tube, and there is a brass ring, or gland, on each packing, *the whole* being held in place by the follower-sheet, F, *which is pierced with holes equal to the inner size of the tubes, and counter-bored to receive the ends of the tubes, which prevents the tubes* from "crawling" out of the nest.

Fig. 6 is a section of the method patented by J. Shields Wilson, of Philadelphia, and which has been successfully used by the Pusey & Jones Company, of Wilmington, Delaware. It has the advantage of

a smaller number of parts than the former method, and of permitting one tube to be removed without in any way interfering with another, while it has the disadvantage of requiring the tubes to be spaced wider apart, the threads cutting away some of the metal of the tube-sheet.

COMING TO ANCHOR.

THE chief engineer should be informed about half an hour before the anchorage is reached, and he should give orders to let the fires burn down. This is necessary, not only as a matter of economy, but of great convenience; if the vessel rushes up to the anchorage at full power, and the engine is stopped, the boilers still making steam, it will be found impossible to check the formation of steam by opening the doors and by feeding with cold water, and it will be necessary to blow-off, greatly to the annoyance of passengers and all other persons on deck. If the fires are heavy, it will thoroughly exhaust the firemen to haul them, or even to bank them; but if they are allowed to burn down for half an hour, they will require much less labor in the hauling or banking.

If the vessel is to remain only a few hours in port, it is best to bank the fires, so that no steam will be formed, but the water will be kept hot in the boilers, and yet not much coal burned. The fires may be banked at the front or at the back of the furnace; if the fire-room is a hot one, it is best (for the comfort of the men) to bank the fire at the back of the furnace, but otherwise not; for when a fire is banked, being covered with good coal, it will burn out at the bottom, while near the top the fuel is clean, and in spreading the fire, by pushing the good coal upon the grate, the ashes and clinkers of the bank should always be hauled out; this is more convenient when the fire is banked in front.

If the vessel is to remain some days in port, the fires should be hauled, and all the water blown out of the boilers through the bottom blows. The bonnets, or covers, should be removed from the cylinder-heads to let the cylinders cool, and the engine wiped down while it is warm. The oil-cups should be emptied and wiped out, and every oil-hole closed to keep out dirt.

When the fires are hauled and wet down, the ashes should be

hoisted in order to clear the fire-room, and then the tubes, fire-boxes, smoke-boxes, furnaces, and ash-pits swept, and those sweepings hoisted out of the fire-room. As soon as the cylinders are cool enough, their interior surfaces should be thoroughly wiped out and coated with clean oil; the follower-bolts should be sounded by a light hammer every time the cylinder is opened, to see if they are tight. When these things are done, the cylinder should be closed, but great care should be exercised to see that the men do not leave anything in the cylinders. The outboard valves should be closed, and the condenser, hot-well, and channel-plate, should be drained. The coal-bunkers should be prepared for coal, *i.e.*, all the braces put up and their pins put in, that the coal may be taken on board. The bilges should now be cleaned and the dirt hoisted, which is the last dirty material sent over the decks; and, this being completed, the decks may be washed and kept clean without further hindrance from the engineer's department. Before polishing the bright work of the engines, it is important to see that all the oil-holes (where there are no oil-cups) are closed, that no grain of emery from the emery-cloth may get into the holes and on the journals; a single grain of emery may cause serious injury, and will certainly cut the journal as long as it remains there. The writer has found plugs of soft pine-wood, luted with tallow, to answer admirably, and it has the advantage of being easily removed. There is more damage done to bearings by grains of emery and brick-dust accidentally or carelessly dropped or rubbed upon them, than by all the other causes combined.

CAPACITY OF COAL-BUNKERS.

WHEN the bunker is situated amidship, and occupies the whole width of the vessel, the floors being above the keelson and nearly parallel with the deck, the capacity of the bunker is calculated as a parallelopipedon, and a reduction afterward made for the curves (the turn of the bilges), and for the knees. The capacity should always be measured as under the beams, because of the great difficulty in stowing coal between the beams. When a side bunker is to be measured, it must be divided into sections, and for convenience in estimating the quantity of coal remaining in the bunker at any period of the voyage, each section should be calculated separately. When conveni-

ent, the sections should be divided upon the frames of the vessel, as there are always permanent indications of those lines.

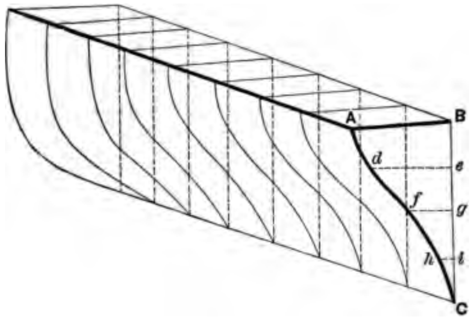


FIG. 7.

Example.—A vessel has side bunkers forty feet long, and the bulkheads are on square frame; the frames of the ship are spaced two and a half feet apart. Then, by dividing the bunker into eight (imaginary) sections, the sections will divide on the alternate frames, or right on the beams.

Measure the lengths of the ordinates, as follows:

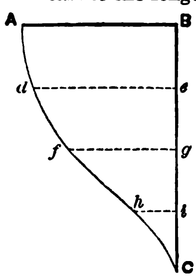


FIG. 8.

		Feet.	Simpson's multipliers.	Product.
A B	=	4.25	1	4.25
d e	=	4.00	4	16.00
f g	=	3.50	2	7.00
h i	=	1.75	4	7.00
C	=	0.00	1	0.00
				34.25

and the sum of the products multiplied by one-third the common interval will be the area of the section. The height of the bunker (B C) is nine feet, and the common interval is $\left(\frac{9}{4}=\right)$ 2.25, so that one-third the common interval will be $\frac{2.25}{3}=.75$, and $34.25\times 0.75=25.68$ square feet. In like manner all the other areas may be found, which are to be arranged as follows:

Areas.	Simpson's multipliers.	Products.
25.68	1	25.68
25.88	4	103.52
26.14	2	52.28
26.30	4	105.20
26.56	2	53.12
26.82	4	107.28
27.08	2	54.16
27.34	4	109.36
27.60	1	27.60
		638.20 = sum.

The length of each section is five feet; and the length of all the sections, forty feet; the cubic capacity of the bunker is 638.2 multiplied by one-third the common interval, or

$$638.2\times\frac{5}{3}=1{,}063.6 \text{ cubic feet.}$$

A ton of anthracite coal can be stowed in forty-two cubic feet, and a ton of bituminous coal in forty-five cubic feet, so that the bunker will contain

$$\text{of anthracite } \frac{1063.6}{42}=25.32 \text{ tons,}$$

$$\text{and of bituminous } \frac{1063.6}{45}\ 23.63 \text{ tons.}$$

PADDLE-WHEELS.

A PADDLE swinging about the centre C, Fig. 9, exerts a pressure on the water in a direction perpendicular to the face of the paddle, and this pressure may be resolved into two components, one, A B, acting horizontally, which will be a useful pressure, and the other, B D, acting vertically, which is lost.

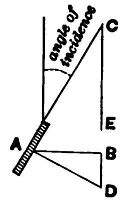


FIG. 9.

The motion of the paddle is also perpendicular at each instant to the surface of the paddle, and is resolved in the same way into useful and useless motion.

Work is the product of pressure and distance, and distance is directly as velocity ; therefore :

as useful pressure : lost pressure :: A B : B D.

also, as useful distance : lost distance :: A B : B D.

$\therefore$ as useful work : lost work :: $\overline{AB}^2 : \overline{BD}^2$.

But the angle B A D is equal to the angle A C E, which is equal to the angle of incidence, and the lines A B and B D are in proportion to the cosine and sine of this angle ; then, the useful work is to the lost work as the square of the cosine is to the square of the sine of that angle.

The slip of a paddle-wheel is the difference of speed between the centre of pressure of the wheel and that of the ship, and is always reckoned in per cent. of speed of the wheel.

The centre of pressure of a paddle-board of a radial-wheel is almost exactly one-third from the lower edge of the board.

Example.—The slip of a paddle-wheel is required. The wheel is 26 feet in diameter over the outer edge of the paddles ; the paddles are 15 inches wide ; the wheels make 15 revolutions per minute ; and the speed of the ship is 10 geographical miles per hour.

The circumference normal to radius to the centre of pressure is 79.06* feet ; the slip will then be

$$\frac{(79.06 \times 15 \times 60) - 10 \times 6080 \times 100}{79.06 \times 15 \times 60} = 14.5 \text{ per cent.}$$

A large wheel loses less power by oblique action and slip than a small one, and is preferred on that account ; but a large wheel mak-

* (26 feet—$\frac{10}{12}$) $\times$ 3.1416=79.06.

ing less revolutions per minute, requires a larger engine to turn it at the same power; besides which disadvantage, the large wheel has weight, cost, and resistance to head-wind against it.

Attempts have been made to lighten engines by lengthening the stroke, and thus increasing the velocity of piston; but the saving, if any, has been small. Increasing the number of strokes per minute

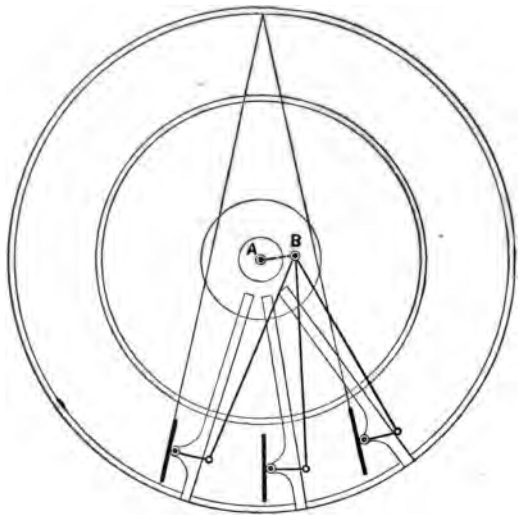


FIG. 10.

for a given power, the pressure per square inch being the same, will reduce the weight of an engine all the way through, and this was most successfully realized in the steam-boat Richard Stockton, many years ago, by using feathering-wheels of smaller diameter, and making more revolutions per minute.

The geometry of the feathering-wheel, Fig. 10, should be such, that

the planes of its paddles in entering and leaving the water are the same as those of a radial-wheel of double the diameter. The Morgan feathering-wheel has its paddles pivoted, and each paddle has an arm secured to it (usually perpendicular to its face), and these arms are connected by rods to a common centre forward of and a little above the centre of the wheel. The expense of building the feathering-wheel is greater than that of the radial, but much more than this difference is saved in the cost of the engine. It is believed in this country that the feathering-wheel will not stand such rough usage at sea as the radial-wheel, nor could it resist so successfully the ice-barriers so common in our northern rivers.

SCREW-PROPELLER.

To form a clear idea of a helix, conceive a right cylinder, Fig. 11, with a circular base, and imagine this cylinder to rotate uniformly about its axis, A B, and, also, that the cylinder has a uniform motion along the line of its axis; then let a pencil be applied to the cylinder at *a*, and let the two-fold motion of rotation and translation be so regulated, that during one complete revolution the cylinder shall progress an axial direction equal to its height; then will the line *a b c*, traced upon its surface, be a helix, and the vertical distance, A B, will be the pitch of the helix, and the pitch will be uniform.

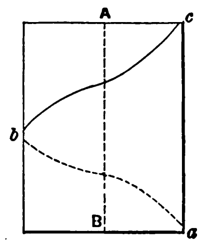


FIG. 11.

But, during the uniform rotation of the cylinder, had the axial-motion been uniformly accelerated, the pitch would have been accelerated, or, as it is technically termed, an expanding pitch.

The screw-propeller is a blade, wound helically around an axis which is parallel with the keel, or nearly so; and to form a clear idea of its warped-surface, conceive the line A B, Fig. 12, to rotate about the line A D, and at the same time to move along the same line, so that it occupies, successively, the positions *a* 1, *a* 2, *a* 3, and *a* 4, then will the surface, generated by the element A B, be a helicoid, which is the working surface of the common screw-propeller. If the element A B rotate with a uniform velocity, and rise with uniform velocity, remaining parallel at all times with the base of the figure,

the pitch of the surface will be uniform on every helix and at every point of the surface, and a screw having such a surface is called a true screw.

But if the generating element A B, should move along the axis A C with an accelerated velocity, while its angular velocity was uniform, the pitch of the surface would be accelerated, and, in a screw propeller, would be said to be an axially expanding pitch.

If one end of the element (B) should move, vertically, faster than the other end (A), while the motion of rotation was uniform, the

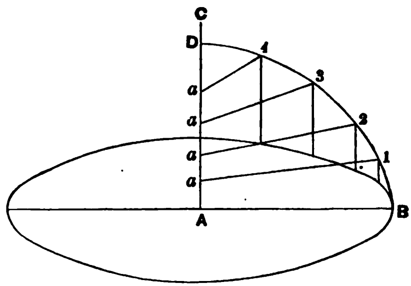


FIG. 12.

helicoid would be a radially expanding-pitch. The axial expanding pitch is the one most used, and the theory is that the leading edge of the blade puts the water in motion, and that the following part of the blade should have a greater pitch in order to exert an equal pressure upon the already moving water.

The pitch of a screw is its axial length for one convolution; that is, the distance it would move, in direction of its axis, through the water for one convolution were there no slip. The whole convolution of a blade is never used; on the contrary, the helicoid is divided into several (usually four) blades, and the aggregate length of all the blades varies between one-third and one-half a convolution. The "fraction of the pitch" is that fraction of the whole helicoid used in all the blades combined.

Slip is the difference between the axial speed of the screw and that

of the ship, and is reckoned in per cent. of the speed of the screw. For example, a vessel made fourteen geographical miles per hour, the screw having twenty-eight feet mean pitch, making sixty revolutions per minute, then the slip was

$$\frac{28 \times 60 \times 60 - 6080 \times 14}{28 \times 60 \times 60} = 15 \text{ per cent.}$$

of the speed of the screw.

It sometimes occurs that a vessel steams faster than the product of the pitch of the screw and its revolutions. This appears paradoxical, and has, therefore, been generally discredited; but it arises from natural causes. It occurs most frequently with bluff and badly modelled ships, the form of which puts the water in motion and causes eddies to follow in the wake, so that the screw works in water which is flowing in its own direction. The United States ships Vandalia and Pensacola, when urged up to a high power, will produce this apparently negative slip. From carefully conducted experiments it appears that neither the expanding pitch nor any form of curvature of blade have produced any superiority of propelling efficiency over that of the simplest form of true screw. Chief Engineer Isherwood, in testing a Herreshoff yacht, tried the experiment of reversing a screw upon the shaft, so that the convex or forward side of the blades was placed aft, becoming the working surface, and the screw gave exactly the same result as it did when working as originally intended.

A screw with two blades is as efficient, as a propeller, as one of a greater number, if it has the same diameter, pitch, and surface; but the less the number of blades the greater will be the shaking or jarring of the ship from the revolutions of the screw. The port in which the screw revolves can be made much smaller for a four-bladed than for a two-bladed screw.

Various forms of curved blades have been designed, and many patented, for the purpose of diminishing the shaking of the ship and for increasing the propelling power. The custom in the Navy has been to curve the blades backward, the generatrix of the helicoid being curved backward in the plane of the axis, and it has been found to diminish the shocks while passing the stern-post. The Hirsch screw answers equally well, the generatrix in this screw being curved in the plane of rotation, being an Archimedean spiral of two degrees for each foot of diameter.

MARINE BOILERS.

SINCE the era of high-pressure steam at sea, marine boilers have been built almost exclusively of cylindrical form. This form of boiler, having less flat surfaces than any other form, requires less bracing and staying, and with high pressures this is a serious matter.

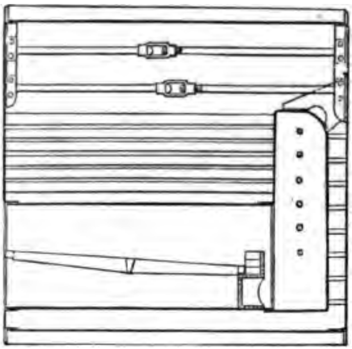


FIG. 13.

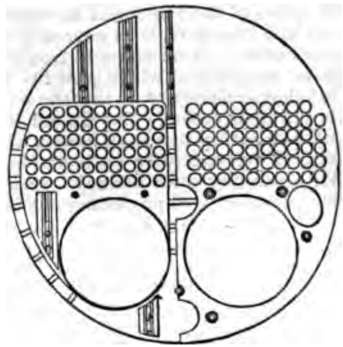


FIG. 14.

Fig. 13 is a longitudinal section of a cylindrical boiler, and Fig. 14 is a transverse section of the same boiler. This boiler is of the horizontal return tubular type, and is distinguished from the common marine boiler of that type only by its external form.

Fig. 15 is the ordinary marine boiler of the horizontal return tubular type, and of rectangular form. The gases of combustion pass through the tubes. A is the furnace; B, the fire-box, or back connection; C, the smoke-box, or front connection; D, the ash-pan; and E, the mud-drum. (This is the boiler of the Lancaster.) This type of boiler is used very generally for pressures of less than fifty pounds.

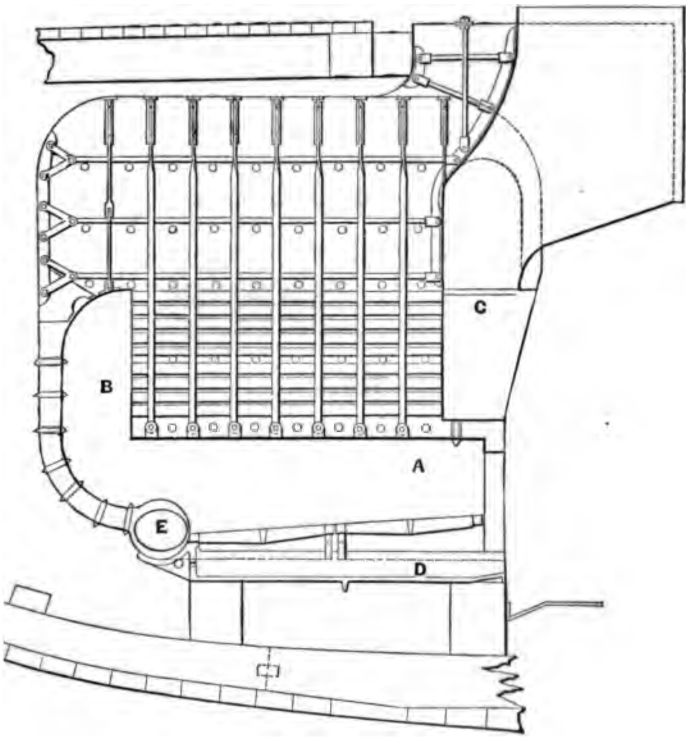


FIG. 15.

Fig. 16 is a Martin boiler, and is distinguished from the horizontal tubular boiler by having vertical water-tubes, with the gases of combustion surrounding the tubes, instead of the horizontal fire-tubes, as described above. Fig. 16 has a water-bottom, while Fig. 15 has only water-legs and a cast-iron ash-pit; but this arrangement of bottom is not inherent to either type. The Martin boiler has given better economic results than any other type of marine boiler, but it has the dis-

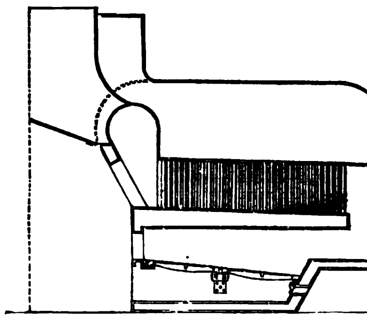


FIG. 16.

advantage of less strength of draught, and requires, therefore, a greater quantity of boiler to do a given work than the fire tubular boiler.

Fig. 17 shows a longitudinal section of a flue and return tubular boiler, such as is in common use on our river-boats, and it is a popular type of boiler. It is heavy, is expensive to build, and takes up a great deal of room; but it is an economical boiler, so far as coal is concerned, and can be placed in the hold of our shallow boats under the deck, with only the steam-chimney above, and as no cargo is carried below decks, the space taken up by the boiler is not needed for any other purposes.

The Herreshoff coil-boiler is rapidly gaining favor for small powers. It is essentially a coil, fed from the top and coupled, at its lower end, with a vessel called a separator. The steam and water flow together,

mixed, into the separator, and the steam is taken from the top of this vessel. A current of water must be continued through the coil without regard to the quantity in the separator, and for this purpose the best possible kind of an independent pump should be used; for should the feed-pump cease working for a minute while the fire is in full action, the coil would probably burn. The Herreshoff boiler is economic in its consumption of coal, and will produce

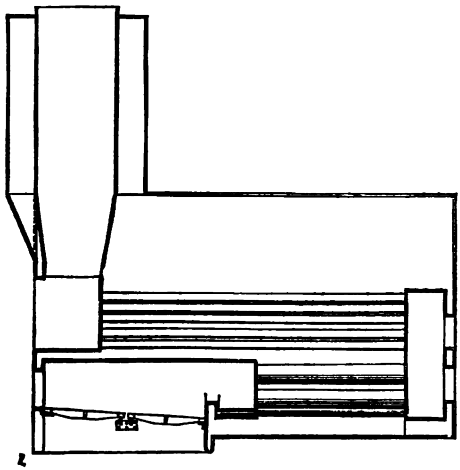


FIG. 17.

a greater power, for equal weight of boiler, than any other known to the writer.

The attachments of a boiler are: the steam and water gauges, feed-valves, blow-valves, safety-valve, stop-valve, salinometer pot, and dry-pipes.

The simplest form of *steam-gauge*, and a reliable one, is the open-top

mercury-gauge. It is filled with mercury up to *a a′*, Fig. 18. If the steam press upon the mercury in the leg *a′*, and force it down one inch, it will be forced up one inch in the leg *a*, making a difference of two inches in the level of the mercury, which will indicate one pound pressure, because a column of mercury with a base of one

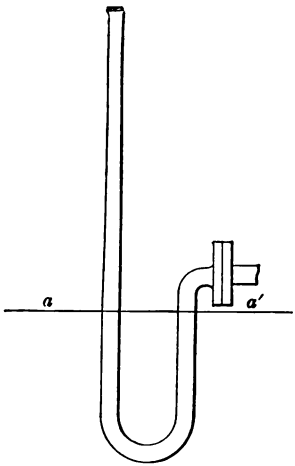


FIG. 18.

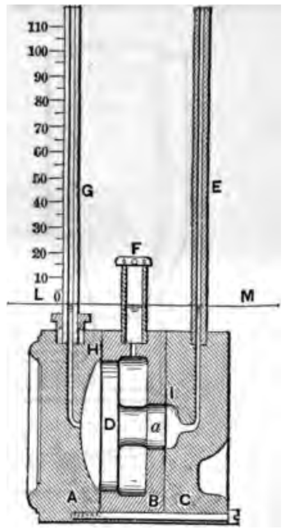


FIG. 19.

square inch and two inches in height weighs, in round numbers, one pound. Therefore, for every inch of rise in the leg *a* there will be an equal depression in the leg *a′*, and each inch of rise in the leg *a* will indicate a pound pressure per square inch. It is not necessary to have the gauge one square inch in area, as the pressure is to be

measured in pounds per square inch. Any reduction in the size of the tube holds good for both the pressure of the steam and the weight of the mercury. For example : if the tube is one-half a square inch in area, a height of two inches of mercury would weigh $2 \times \frac{1}{2} \times 1 = \frac{1}{2}$ pound, and this would balance, in pounds per square inch, an area of half a square inch $\times$ 1 pound per square inch, or $\frac{1}{2} \times 1 = \frac{1}{2}$.

An excellent form of high-pressure mercury-gauge is the open-top gauge of Chief-Engineer A. S. Greene (Fig .19). It is made of three iron disks bolted together, and contains a double piston D and *a*, having rubber diaphragms, H and I ; a gas-pipe E is screwed into the edge of the outer disk, and connects with the space at the back of the small piston, and this pipe connects with the boiler. In the middle disk the gas-pipe, F, is screwed, which opens into the chamber between the pistons D and *a*. The glass gauge-tube is secured to the front disk, and communicates with the chamber in front of the large piston D. The tubes, G F and E, are all open at the top, and are filled up to the zero line, L M, in which condition everything is balanced. This gauge is almost perfectly self-adjusting from varying temperatures. The relative height of mercury in the tubes G and E will be inversely, as the areas of the pistons D and *a*, and, in this way, a short tube, G, may be used to measure a high pressure.

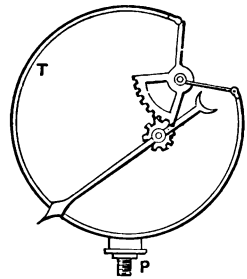


FIG. 20.

The most popular form of spring-gauge is that of Bourdon, Fig. 20. It has an oval tube, T (with its greatest diameter perpendicular to the plane of curvature), into which the pressure enters at the pipe, P. It has a toothed-arc and pinion, a pointer, and a dial. The pressure in the tube, T, tends to straighten it, which, through the arc and pinion, revolves the pointer, which indicates the pressure on the dial. The elasticity of the metal in the tube is all that resists the steam-pressure.

Another form of spring-gauge, equally as good as the former, is the Utica steam-gauge, Fig. 21. It is a kind of corrugated drum, with the heads brazed on.

The steam-pressure is inside the drum, and is resisted by the elas-

ticity of the metal, its motion being communicated to a pointer through suitable mechanism.

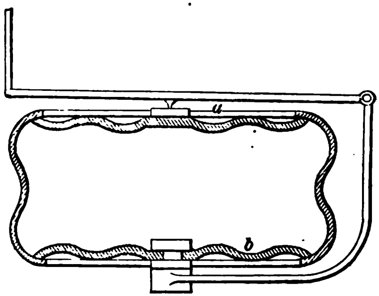


FIG. 21.

There are two kinds of water-gauges in common use: the glass-gauge, Fig. 22, and the gauge-cock, Fig. 23. There are various forms

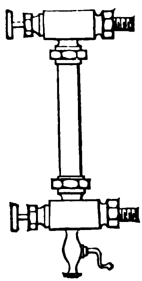


FIG. 22.

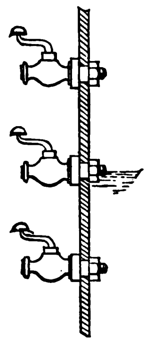


FIG. 23.

of combination-gauges in use, some of them patented, but the writer's *experience* teaches him that these gauges are better when separate,

and that they should be tapped into the shell of a boiler with the shortest practicable connections. The glass-gauge has a valve or cock at each end, to close it off in case of accident to the glass, which enables you to put in a new glass while the pressure is in the boiler. At the bottom of the glass-gauge there is usually a blow-through cock; by closing off the top of the gauge, and opening the blow-through cock, the bottom passage of the gauge is cleared; and by closing the bottom passage of the gauge, the blow-through will clear the top opening.

Gauge-cocks should be tapped directly into the shell with a nut on the inside of the boiler. They should always be in an accessible

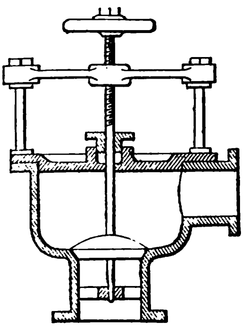


FIG. 24.

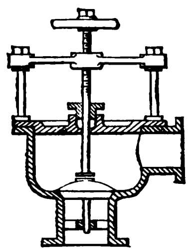


FIG. 25.

place. Where it is imperative to put a connection between the water-gauge and the boiler, it should be larger in area than the cock, and should be frequently cleared.

There are two blow-valves on a boiler: the bottom- and the surface-blow. The surface-blow, which takes the water from near the surface, is used almost exclusively where the jet-condenser is employed, as it is most economical to keep up a steady blow; and the theory is, that as the evaporation is from the surface of the water, that the water there will be denser. The bottom-blow is used not only to blow the

water out of the boiler, but to run water in when the boilers are cold.

Feed or check-valves, Fig. 25, are always attached to the boilers, and all the water pumped into the boiler passes through the check. It is detached from the stem, and automatically prevents any water passing from the boiler into the feed-pipe, which would otherwise occur in the event of accident to the feed-pump or pipe. Check-valves are sometimes made with a detached screw-stem, by which their lift may be regulated and the quantity of feed-water gauged to a nicety, by which means several boilers may be fed with one pump. Where only one boiler is used, the screw-stem is not necessary, and an unthreaded-stem with a weight on it takes its place, while the feed supply is regulated by the pump alone. A "steady feed" is one of the

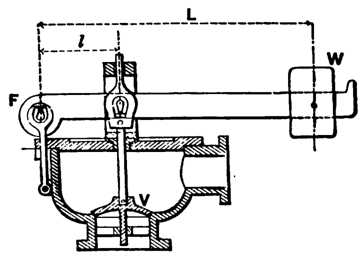


FIG. 26.

things greatly to be desired in an engine-room—it conduces to a uniform steam-pressure and speed of engine, and under these conditions the boiler is not apt to foam.

Fig. 26 is a section of the safety-valve brought to Washington, in 1875, by the Supervising Inspectors of Steam Vessels, in competition with which many patented valves were tested, but none were found superior to it, nor of simpler construction. It differs from the common safety-valve only in having knife-edges on the lever.

In loading a safety-valve, the measurements of the lengths of the arms of the lever are all made from the fulcrum, F. The long arm is the projected length from the centre of F to the centre of gravity

of the weight, W, and the short arm is the projected length from F to the centre-line of the valve-stem. Leaving weights and friction out, the simple equation $P\,l = W\,L$, solves the safety-valve, in which P = the load on the valve, and W = the weight. The simplest practical way to load a safety-valve is to remove the weight, W, attach a spring-balance to the valve-stem, V, and ascertain the weight required to lift the valve, stem, and lever. This is a constant pressure, always *seating* the valve, no matter where the weight may be. The pressure to be lifted by the steam is this pressure plus the effect of the weight, or the pressure found by multiplying the area of the valve by the pressure per square inch, and then deducting the amount found by the spring-balance. After this, proceed as if there were no friction, nor weight of lever, stem, etc.

Example.—A safety-valve is 8 inches in diameter, and it is required to blow-off at 40 pounds per square inch; the weight, W, being 190

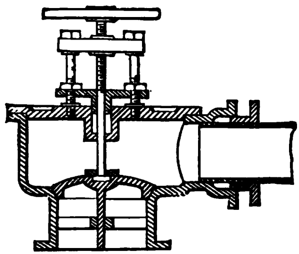


FIG. 27.

pounds; 150 pounds being required to lift the valve, stem, and lever; and the short arm, l, of the lever, being 5 inches; required the distance the weight, W, must be from the fulcrum.

The diameter of the valve being 8 inches, the area will be ($\pi r^2 =$) 50.265 square inches, and

$$L = \frac{(50.265 \times 40 - 150) \times 5}{190} = 48.9 \text{ inches.}$$

Fig. 27 is the section of a boiler stop-valve with a slip-joint.

They are usually made with the stem movable in the valve, and with outside threads, and are so placed on the boiler that the pressure will be under the valve. The slip-joint, as its name implies, is a pipe-connection wherein one pipe slides or slips within another. These are packed like other stuffing-boxes. They are indispensable on board sea-going ships when there is a great length of straight pipe, or where they connect engines, boilers, or pumps which are not on the same bed-plates. Copper or brass pipes, of small size, having elbows or curves sufficient to allow considerable spring, do not require slip-joints.

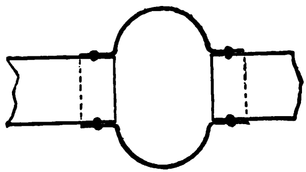


FIG. 28.

Instead of a slip-joint, the expansion-joint, Fig. 28, is sometimes used. It is used almost exclusively on exhaust-pipes. It is a short semi-annulus of copper, connecting the two ends of the pipe. The object of these joints is to compensate for any alteration of the length or direction of the pipes, either from the working of the ship or from the effects of heat and cold.

Salinometer-Pot.—Drawing water from the boiler for the purpose of testing its density is always attended with considerable inconvenience, and some danger of scalding one's hands, for the water flowing from the boiler has a temperature due to the pressure in the boiler, which is considerably above the atmospheric boiling temperature. If the water be drawn off very slowly, the rapid boiling is avoided, but the engineer has not usually time for this. To avoid this difficulty, the circulating Salinometer-pot was devised by Chief Engineer Fithian. (Fig. 29.) It contains a small coil, through which the water flows, and around which cold water circulates, which cools the boiler-water down to 200° very quickly, and completely prevents *the boiling*-over.

Boiler-plate in this country is known under three designations which indicate not only the quality of the plate, but the process of manufacture.

C. No. 1 signifies charcoal number one, and refers to iron manufactured in the blast-furnace employing charcoal as fuel. It is used in those parts of boilers which are not subjected to high degrees of heat, *i.e.*, in the shells, and not in the furnaces.

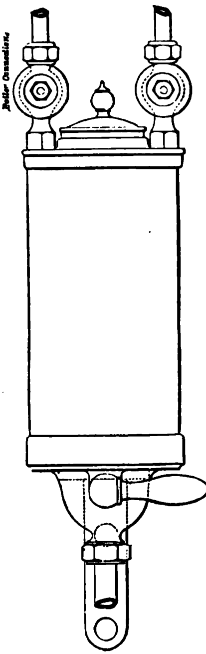


FIG. 29.

C. H. No. 1 means charcoal hammered number one, and comprises plates in which the piles are reheated and hammered with heavy steam-hammers. This process makes the plate more compact and solid, improves the strength of the plate, and makes it more capable of standing high heat. This is "flange-iron."

FIRE-BOX iron designates a kind of plate made exclusively for furnaces.

There are different qualities of these different brands, depending on the process and care of the various manufacturers.

For C. No. 1 the iron used is generally cold-blast charcoal-iron. The pig metal is remelted, and refined or converted into wrought iron in charcoal-fires, the balls being hammered into blooms. These blooms are reheated in reverberatory furnaces, and then rolled into slabs, which are called covers. Between two covers the clippings of boiler-plates are placed, and the "pile" is then brought to a welding-heat and passed between heavy rollers.

Common wrought-iron scrap is sometimes piled between covers, and the risk of obtaining inferior iron is thus increased, owing to imperfect welding of the pieces from the presence of slag between the layers. Iron manufactured by this process of covers and filling is liable to blister under intense heat, on account of its laminated character and from imperfect welding.

C. H. No. 1 is made by piling one bloom or slab upon another, no scrap being introduced between the blooms ; or by compactly piling bars at right angles to each other, the piles being rolled under a high welding heat to compact the mass, which is reheated and re-rolled several times.

Fire-box or flange-iron is made in a similar way to C. H. No. 1, and differs only in being subjected to one or two additional processes of heating and hammering, or rolling, in which the greatest care is observed in the selection of the material.

It is difficult to detect the quality of boiler-plate by superficial examination, as the surfaces appear so nearly the same. As a rule, plate-iron which can be bent at right angles when red-hot without showing cracks is good for any part of a boiler, and this test, if made cold, is still more favorable.

When plates are not solid, but in layers, they are said to be laminated. This condition arises from imperfect welding of the layers, and is usually caused by sand or cinder being interposed, and which has not been expelled in the rolling and hammering in the process of manufacture.

Blisters arise from the same cause as lamination. Sometimes a blister appears as a mere surface defect, and is of little consequence; but their appearance may be an indication of the lack of care in the manufacture.

All plates which are to come in contact with the fire should be sounded before being used. This is done by hammering with a light hammer (about one and one-fourth pounds) all over. If the plate is good, the sound will be clear and the hammer will fall heavy upon it ; but if there are blisters, the sound will be dull, and the hammer will rebound. Sometimes a plate will appear good on one side and blisters be found on the other ; therefore, plates should be sounded on both sides.

SLIDE-VALVES.

THE slide-valve is used almost exclusively on screw-propeller engines, and it is the one which invites the most discussion. Fig. 30 shows a common slide-valve in the central position, where the ports are closed ; and Figs. 31 and 32 the two extreme positions where the ports are wide open.

When a slide-valve has no lap, as in Figs. 30 *et seq.*, the width of the facing is just enough to cover the ports, the *lap* being any additional width whereby these ports are overlapped.

The distance through which this valve moves in passing from one extreme position to another is called the *travel*, which, in this case,

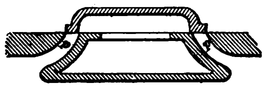


FIG. 30.

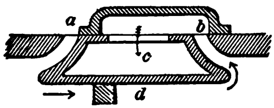


FIG. 31.

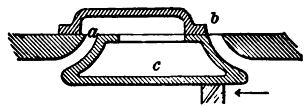


FIG. 32.

equals twice the width of port, and always equals twice the throw of the eccentric.

In Fig. 31, the steam enters the port a, and urges the piston, d, to the end of its stroke, while the steam from the right-hand end of the cylinder is being exhausted through the port b.

In Fig. 32, where the piston has reached the end of the stroke, the valve has shifted its position so as to allow steam to enter the port b, and to exhaust through a into the exhaust opening c.

This is the simplest form of the slide-valve; but as it permits the steam to follow the piston to the end of its stroke without cutting off, and thereby taking advantage of the latent power of the steam's expansibility, it is seldom used in this form. The cut-off with the slide-valve is effected in two ways; first, by adding *lap* to the valve, and second, by an independent cut-off.

Lap is the amount the valve extends over the ports when it is in mid-position. *By adding lap to the valve, as indicated by the black lines in Fig. 33, we cause its edges to cover the ports earlier and thus cut off the steam. When lap is added to a valve it is evident that the

* For a thorough investigation of the slide-valve, we recommend Auchincloss' or Zeuner's works.

valve will not open soon enough; we must, therefore, set the eccentric ahead sufficiently to meet this amount, and the number of degrees we set the eccentric ahead for this purpose is called the *angular advance.* When we set the eccentric ahead, we not only correct the time of the steam opening, but we open the exhaust just that much too early, and it becomes necessary to add lap to the exhaust side *b*, Fig. 33. If the same lap were added to the exhaust side as to the steam, it would cause the exhaust to close too early and produce too great *cushioning*, so a smaller amount is applied to the exhaust side. By careful designing, the slide-valve can be made to cut off at two-thirds of the stroke with a very good distribution of the power.

For shorter cut-offs, an independent cut-off valve, driven by an independent eccentric, is used. Fig. 34 shows such a valve, with the

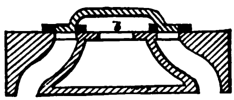


FIG. 33.

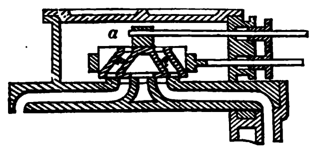


FIG. 34.

cut-off valve *a*, sliding over the ports of the main slide-valve, by which motion it closes the ports.

When a valve opens before the piston has reached the end of the stroke it is said to have *lead.* When the journals of an engine are not well-fitted, the engine will *thump* upon the centres, but if the valve has lead, the motion of the piston toward the end of the stroke is resisted more gradually by the steam, and the lost motion is taken up gradually, which prevents the shock called *thumping.* In small engines it is possible to fit the journals so well that there will be no thumping, but in large engines this is impossible.

Lead is the amount of opening a valve has when the piston reaches the end of the stroke, and the *lead-angle* is the angular-distance of the crank from its zero when this *lead* commences. *Cushioning* is effected by closing the exhaust before the piston reaches the end of the stroke and prevents thumping in the same manner as *lead* does. Engines having large clearance-spaces at the ends of the cylinders, and in the *valve-ports,* are made to *cushion* up as nearly as practicable to the

terminal cylinder-pressure, as a matter of economy, and it matters little whether such an engine has lead or not.

The double-ported slide-valve is used very extensively on marine engines. Fig. 35 is the L. P. valve of the U. S. Steamer Trenton.

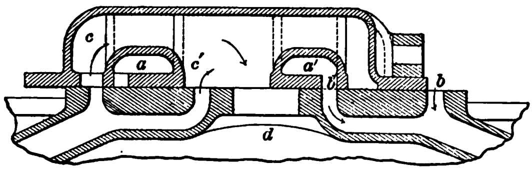


FIG. 35.

There are openings, or pockets, in the sides of the valve *a a'*, which take steam from the steam-chest. As shown, the cylinder is taking steam at *b b'*, and exhausting at *c c'* into the exhaust-passage *d*. The double-ported valve is used in preference to the single-ported, as it effects the same opening with less travel.

Motion is communicated to the valve from the shaft, by a device

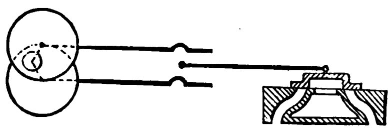


FIG. 36.

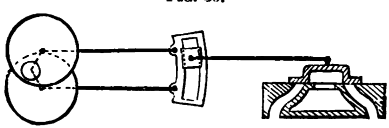


FIG. 37.

called an eccentric, a subterfuge for a crank. There is one eccentric for the go-ahead motion and one for the backing motion, and formerly there was a hook on each eccentric rod, one of which had to be hooked

on to a pin on the valve-stem, to make the engine work. By unhooking the go-ahead and hooking on the backing-eccentric the engine was reversed. Stevenson joined the hooks and made the *link*, so that one end of the link, when over the pin (the pin is surrounded by a sliding-block called the *link-block*) put the engine in the head-gear, and when the other end of the link is over the pin the engine is in the back-gear. Fig. 36 shows the old hook-motion, and Fig. 37 shows the link-motion in the go-ahead gear. It requires considerable power to

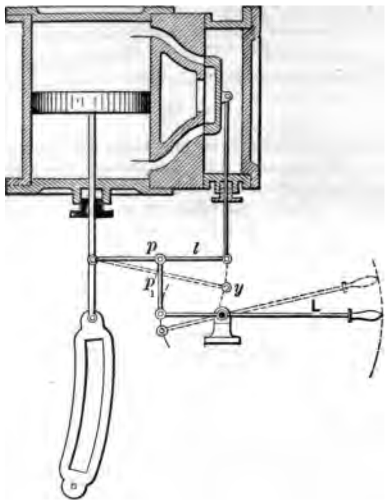


FIG. 38.

throw the link from one extreme position to the other, and to effect this, reversing engines have been devised. The best reversing engine known to the writer is the kind built by the Messrs. Cramp, at Philadelphia, and applied to all the large marine-engines built by that firm. *Fig.* 38 will be sufficient to illustrate the principle. If the

lever L be raised to the position indicated by the dotted line, it lowers the point *p* of the floating-lever *l* to the point *p'*, and opens the steam-valve at the top; this forces the piston down, and *p* now being the centre of motion of the floating-lever *l*, the point *y* is elevated until the valve is closed. This automatic machine is so regulated that when the lever L is thrown to its limit, the piston, and likewise the link, will go to the limit and stop automatically. With this arrangement it is possible to handle the engines of the largest steamer as quickly as those of a tugboat.

Slow-working engines in this country are provided with poppet-valves, as represented in Fig. 39. This is the double-poppet, or

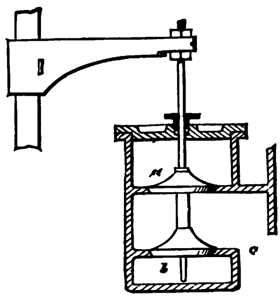


FIG. 39.

balanced poppet-valve, so generally used on our paddle-wheel steamers. The steam presses on top of the valve *a*, and tends to seat it, while the same pressure tends to lift *b* from underneath, but the two valves being secured to the same stem, and the top valve being a little larger, there is a preponderance of pressure to seat them. This difference of size is sufficient to secure the proper seating of the valves. When the valves lift, the steam flows through the port *c* into the cylinder. It requires less power to work these valves than any other kind, and the loss by clearance in our ordinary beam-engine is only about half that of the slide-valve tugboat engines built by the

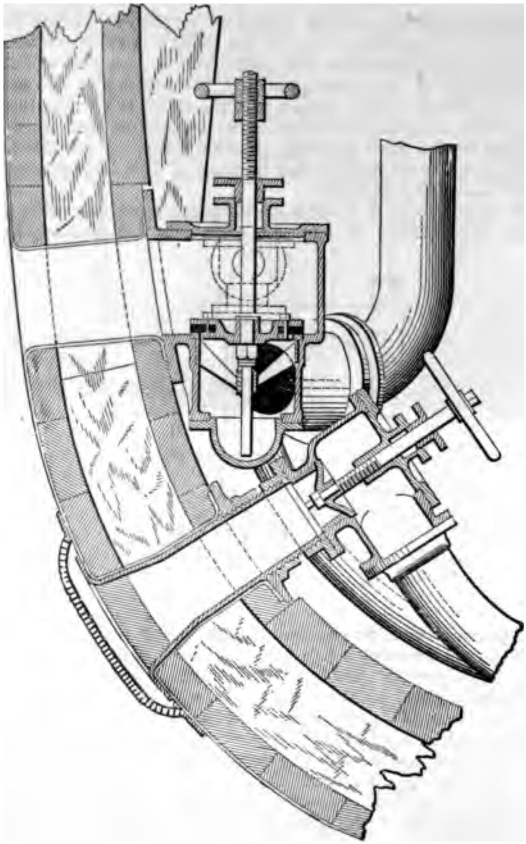


FIG. 40.

same firms. As the poppet-valve depends on gravity to seat it, and as it must seat gradually, it is not used on quick-working engines.

Sea-Valves.—Fig. 40 shows a section of the injection and outboard delivery-valves of the gunboat Nyack. There is not such great precaution taken in fitting the outboard delivery-valves as in the injections, as they are near the water-line, and are more accessible. As the water flows *from* the delivery, no strainer is required, thus leaving the hole open, which enables the engineer to plug it up when repairs are necessary. For an injection-valve the hole is carefully bored through the wood, and then counter-bored, conically, at the outer end. A lining of sheet-copper is then put in, having its seam brazed; the ends of this copper lining are then flanged over and secured to the surface of the ship, both inside and outside. A heavy brass pipe, fitting this hole, is then pushed in, and a washer and nut on the inboard end pull it tightly in place. The pipe is then secured tightly, at its outer flange, to the ship by copper screws, after which the strainer is secured by screws. A flange is screwed to the inboard end of the pipe, and the valve bolted to this flange. The outboard delivery has the same lining through the wood, but the chamber is bolted to the wood of the ship, on the inside, by brass wood-screws. On large ships there is a ring of brass on the outside, and the valve-chamber is held by through-bolts. The "donkey" pumps and the main bilge-pumps discharge, through a check-valve, into the outboard delivery, *above* the valve. It is now the navy practice to use rubber faces on the injection and delivery-valves, and to make the delivery-valve a check.

Where sea-valves pass through the vessel above the permanent filling-pieces, there are special filling-pieces supplied, that the piping may pass through solid wood.

STEERING APPARATUS.

THE use of steam for steering ships is of comparatively recent origin, but it has proved satisfactory, and there is indication of its coming into general use. An engine for this purpose must be of such simple construction that skilled labor is not essential for its successful operation; it must be certain in its action, it must be noiseless, and automatic to a certain extent; that is, it must push

the helm over a number of degrees depending on the volition of the man at the wheel, and must stop automatically when that angle is accomplished. It must be so arranged that, in the event of accident to the steam-engine, it can be detached and the hand gear thrown into use in a moment. Fig. 41 is a longitudinal view of

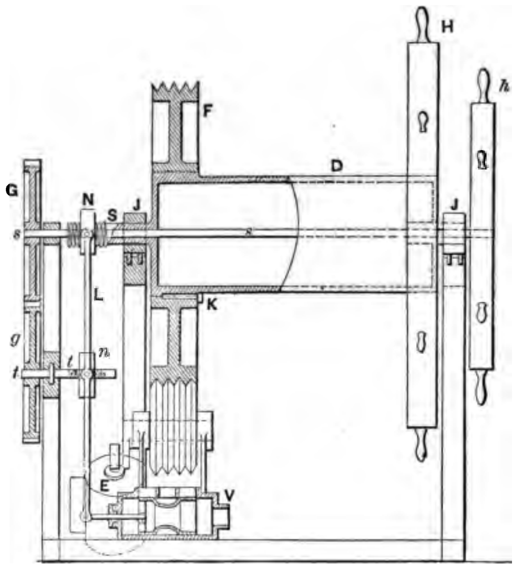


FIG. 41.

a steam steering and hand-power machine, combined; the right hand showing an elevation and the left hand a section. The steam steering-wheel *h* communicates motion to the steam reversing valve V, through the intervention of the shaft *s*, gear wheels G and *g*, the nut *n* on the screw *t*, and through the floating lever L. When the

valve V is opened the engine E revolves, and through the friction (noiseless) gear-wheels revolves the drum D, on which the tiller ropes are coiled; but when the drum D revolves, its prolonged axis, S, on which there is a screw and a nut, N, also revolves and moves the floating lever L so as to stop the engine E, and it is so proportioned that one revolution of the wheel *h* will cause one revolution of the hand-wheel H, at which moment, the valve V being closed, the machine stops itself.

By withdrawing the key K, the friction-wheel F becomes loose upon the drum, and steering may be done by hand, entirely independent of the power gearing.

DISTILLED WATER.

SINCE the introduction of distilling apparatus on board the ships of the navy, diarrhœa has diminished more than fifty per cent. This arises from the uniform quality of the water, for men are frequently attacked by a temporary diarrhœa from simply a *change* of water. Ships taking water from various ports, even though great care be exercised, are almost certain to get bad water once in a while. Gibraltar has a much frequented harbor, and ships stopping there almost invariably take in water. The water is drawn from a well on the neutral ground. Before the well was sunk there was always water found in digging new graves in the adjacent cemetery, but since that event the graveyard is dry. It is not necessary to add that the well has drained the cemetery. Hard rains sometimes cause a rise of water in the sewers, in our large cities, and the *head* of water being greater than that in the adjacent springs and wells, there is a leakage of sewage through the soil into the wells, and the water is contaminated. This happened in a suburb of Philadelphia, only a few months since, which resulted in an epidemic of typhoid fever. The head of water in the sewer was greater than that in the spring for only a few hours, and the sewage had to percolate through about ten (10) feet of soil, besides the brick lining of the sewer, before it reached the spring. This spring had supplied the neighborhood with water for many years, and no suspicion rested on it until the eminent chemist Dr. Haines made analyses. Any apparatus which will condense the steam from the boiler without mixing *anything else with it will* make fresh water, but that water must

lie in tanks, exposed to the air, for some days before it is fit to drink. It contains organic matter which the air must have time to oxidize, and it is flat and insipid from the want of aëration.

The cost of distilled water at sea depends on the cost of the coal used, and on the efficiency of the boiler, and is entirely independent of the kind of distiller used.

The average price paid for coal for the navy, the world over, from 1869 to 1877, was $10.32 per ton, or $(\frac{1032}{2240}) = \frac{46}{100}$ cents per pound.

The evaporative power of marine boilers is from 7 to 12 pounds of water per pound of coal, and the distilling apparatus is proportioned to condense all the vapor its pipe will bring.

A gallon of distilled water weighs $8\frac{1}{3}$ pounds, and assuming, for example, that a boiler evaporates 7 pounds of water per pound of coal, a gallon of water will cost $(8\frac{1}{3} \div 7 =)\ 1\frac{4}{21}$ pounds of coal, or $(1\frac{4}{21} \times \frac{46}{100} =)\ \frac{547}{1000}$ cents. Adding to this the loss incurred in blowing the boiler, which will not exceed 20 per cent., we have a cost of 0.656, a little over $\frac{6}{10}$ of a cent per gallon.

A ton of distilled water will occupy 35.84 cubic feet, and a ton of coal will distil $(7 - (\frac{1}{5} \times 7) =)$ 5.6 tons of water. A ton of coal occupies about 42 cubic feet, so that by carrying coal instead of water we save space in the ship for other things in the ratio of 5.6 to 1; or, instead of carrying 195.1 cubic feet of water, will carry 42 cubic feet of coal, leaving 153.1 feet for cargo.

Freshly distilled water has a flat, insipid, oleaginous taste, but becomes sweet and potable in from ten to fifteen days' exposure to the air. Its potability may be hastened by artificial aëration, and this may be done by a fountain,* by blowing air into the tanks,* or by the patented aërator, which forces the air into the steam before condensation. The first and second methods require to be oft repeated, and much time is necessary before the aëration is sufficient.

The organic matter brought into the still by the steam is oxidized by the great quantity of hot air present, as induced by the patented aërator, and is put in a condition to be removed by a proper filter. By placing the aërator some distance from the still, and by the addition of a small quantity of oxygen gas to the air used, the water has been made so good that it was difficult to distinguish it from hy-

* Journal of the Franklin Institute, vol. lxiii., page 68.

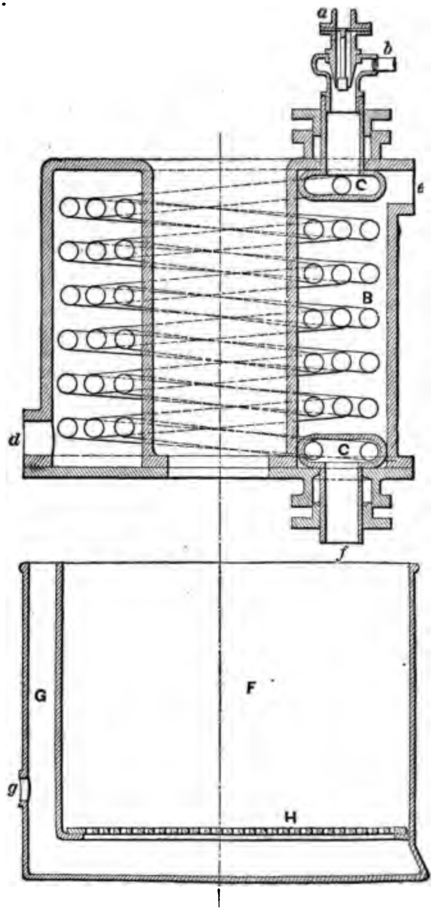


FIG. 42.

drant water; but the cost and complication incident to this method has decided the inventor to use the pure air alone. By this simple method the water is distilled pure and sweet enough to drink at once, and after it has been made twelve hours—long enough for any solid matter to precipitate—it has the taste of hydrant water.

Fig. 42 is a section through the condenser, aërator, and filter, which has been generally adopted. The steam enters the aërator at *a*, and is thrown into the coils B through C, in an annular jet. Atmospheric air is induced through the pipe *b*, and mixes with the steam before it reaches the coils. In the coils (which are of block tin) the steam is condensed, and incloses and absorbs air to its saturation. The shell of the condenser, of cast iron, is made annular (to improve the circulation), and the circulating water enters at *d* and passes out at *e*. The fresh, aërated water flows through *f* into the filter F, which contains granulated animal charcoal which has been chemically purified for this purpose. A pipe at *g* carries the water to a meter, and it flows thence to the tanks. This apparatus is built by the Davidson Pump Company, at 41 to 47 Keap street, Brooklyn, and is patented.

KINDS AND TYPES OF ENGINES.

There are recognized two kinds of steam-engines: the non-condensing and the condensing. These are subdivided into single-expansion and double-expansion or compound engines.

The non-condensing engine exhausts into the atmosphere, and works against that pressure, and it may be either single expansion or compound.

The condensing engine exhausts into a condenser, where the pressure of the atmosphere is, as nearly as possible, removed. The condensing engine may also be either single expansion or compound.

The arrangement of the relative parts of an engine constitutes its type.

Fig. 43 is a side-lever engine.
Fig. 44 is a half-beam or half-lever engine.
Fig. 45 is an over-head beam engine.
Fig. 46 is a vertical oscillating engine.
Fig. 47, inclined oscillating engine.
Fig. 48, horizontal direct-acting engine.

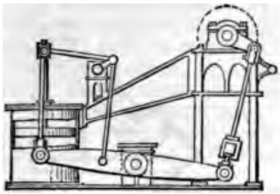


FIG. 43.

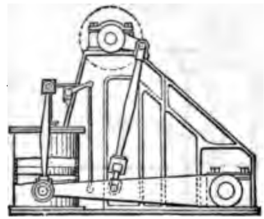


FIG. 44.

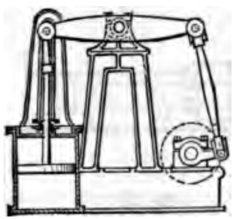


FIG. 45.

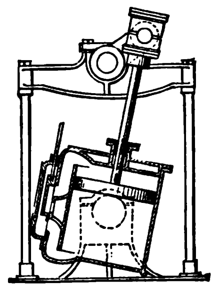


FIG. 46.

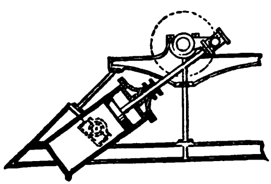


FIG. 47.

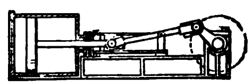


FIG. 48.

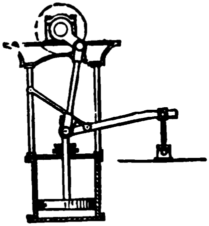


Fig. 49.

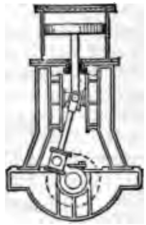


Fig. 50.

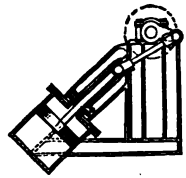


Fig. 51.

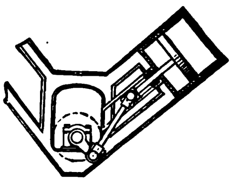


Fig. 52.

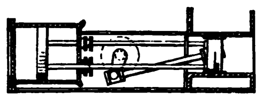


Fig. 53.

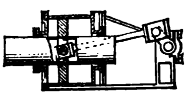


Fig. 54.

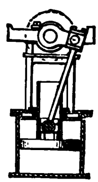


Fig. 55.

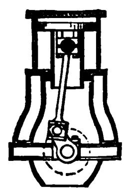


Fig. 56.

Fig. 49, vertical direct-acting engine.
Fig. 50, inverted direct-acting engine.
Fig. 51, inclined direct-acting engine.
Fig. 52, direct-acting, inclined downward.
Fig. 53, horizontal back-acting.
Fig. 54, horizontal trunk.
Fig. 55, vertical half-trunk.
Fig. 56, inverted half-trunk engine.

Of these there are three types in extensive use in our marine. The over-head beam engine (Fig. 45) is used largely on board our river steamers, the beam being a *skeleton beam* instead of a solid beam, as shown.

The inverted direct-acting engine (Fig. 50) is used almost exclusively for mercantile screw-propeller vessels, from the largest ocean steamer to the harbor-tug.

The horizontal back-acting engine (Fig. 53) is the type principally used in the screw-propeller ships of war of all nations.

PUMPS.

INDEPENDENT pumping engines are now used on board all steamships, and on board nearly all steamboats. A "donkey-pump" should have a valve-gear, which will cause it to start from any position by merely opening the throttle. In the Davidson, Cameron, and Blake pumps this is accomplished by a "steam-actuated valve," but in the Worthington duplex by a positive valve motion, by using a pair of pumps, the valve of one steam cylinder being moved by connections from the piston-rod of the other.

The makers of first-class pumps are now using on the water-end a large number of small valves, and have found the pumps so constructed to throw more water than by using a smaller number of large valves of the same aggregate area. They not only throw more water, but the valves require less lift, and consequently produce less shock in seating.

This is correct for clean water, particularly where the pump is working against great pressure; but for a bilge-pump it is objectionable, because dirt, chips, small pieces of boiler-felt, waste, etc., which clog up the small water-valves would pass through larger

valves. This dirt may be arrested by a strainer (preferably a basket-strainer), but if the holes in the strainer be made very small, it will be constantly choking up.

There should be at least two donkey-pumps on every steamer, and one should be a special clean-water pump, and the other a special bilge-pump. Both should be piped, as they are now, for all work, but not used for other work than that for which they are intended, except in emergencies. It is an unwritten law among engineers never to let the donkey feed-pump be used for any purpose except feeding the boilers or for fire purposes; and when it is known how easy it is to choke up a pump with bilge dirt, and also how embarrassing it is to an engineer to find the donkey feed-pump refuse to feed the boiler, we must respect that unwritten law. A careful engineer will always wash out his pump by pumping sea-water, after having pumped the bilge, and this should never be neglected. The Davidson Pump Company make their water-valve openings exceedingly large, and put in the kind of valves according to the duty required of the pump. One kind of valve is used for hot-water, another for cold (clean) water, and still another kind for bilge-water. All pump-builders use a brass lining, brass valve-seats, and brass-covered rods in the water-ends of pumps to be used for sea-water. The steam end of the improved pumps, such as the Davidson and the Worthington, are so perfectly made now that they can be throttled down to one stroke a minute, with a certainty of continuous running so long as the steam is supplied, and the steam-thrown valves are so nicely adjusted that when the piston reaches the end of the stroke the steam-valve will then be "thrown" from one full opening to the other. With such perfect pumps, ordered for special purposes, the unwritten law must soon become a "dead letter," and the steam-pumps used for washing decks and for all other purposes whereby labor can be saved.

Section 9.

SPEED TRIALS.

REMARKS ON THE TURNING OF SHIPS.

PRACTICAL METHOD OF MEASURING A SHIP'S CIRCLE.

WAVES.

OBSERVATIONS OF THE DIMENSIONS AND PERIODS OF WAVES.

METHODS OF OBSERVING THE ROLLING AND PITCHING MOTION OF SHIPS.

DISPLACEMENT AND BUOYANCY.

FREEBOARD.

THE TONNAGE OF SHIPS.

SAILING, ETC. CENTRES OF EFFORT AND LATERAL RESISTANCE.

USEFUL RULES IN MENSURATION, ETC.

THE LIFE-SAVING SERVICE.

INSTRUCTIONS FOR MASTERS AND SEAMEN IN CASE OF SHIPWRECK.

LOCATION OF LIFE-SAVING STATIONS.

HINTS TO BATHERS.

INSTRUCTIONS FOR SAVING AND RESTORING

DROWNING PERSONS.

ACCIDENTS, INJURIES, AND POISONS. WATER.

SHIP PAPERS.

FOREIGN SEA TERMS AND PHRASES.

SPEED TRIALS.

Measured Mile.

To determine the true speed of a vessel when the runs are taken on the measured mile, half the number of runs being taken with the tide, and half against the tide.

RULE.—*Find the means of consecutive speeds continually found, until only one remains.*

EXAMPLE.

Runs.	Knots.	1st means.	2d means.	3d means.	4th means.	Mean of means.
1st						
	15.4					
2d		12.75				
	10.1		12.475			
3d		12.20		12.45		
	14.3		12.425		12.425	
4th		12.65		12.40		12.46875
	11.0		12.375		12.36875	True mean
5th		12.10		12.3375		speed.
	13.2		12.300			
6th		12.50				
	11.8		4)49.575			
	6)75.8		12.39375, Ordinary mean of second means.*			
	12 633, Ordinary mean speed.					

* The ordinary mean of second means is generally taken as sufficiently accurate.

Speed of the Current.—To find the speeds of the current in the line of the ship's course during her speed trials.

RULE.—*Find the differences between the real speed of the ship, and her observed speeds on the mile during the several runs.*

EXAMPLE.

Runs.	Observed Speed.	Real speed.	Differences.	
1st	15.4	12.469	2.931	Knots with the ship.
2d	10.1	12.469	2.369	" against " "
3d	14.3	12.469	1.831	" with " "
4th	11.0	12.469	1.469	" against " "
5th	13.2	12.469	731	" with " "
6th	11.8	12.469	679	" against " "

Time and Knot Table.

The minutes and seconds of time, in which a vessel passes over the measured mile, being known, the corresponding number of this table, will be the speed of the vessel in knots.

Sec.	3m.	4m.	5m.	6m.	7m.	8m.	9m.	10m.	11m.	12m.	13m.	14m.
0	20.000	15.000	12.000	10.000	8.571	7.500	6.606	6.000	5.454	5.000	4.615	4.285
1	19.890	14.938	11.960	9.972	8.551	7.484	6.654	5.990	5.446	4.993	4.609	4.280
2	19.780	14.876	11.920	9.944	8.530	7.468	6.642	5.980	5.438	4.986	4.603	4.275
3	19.672	14.815	11.880	9.917	8.510	7.453	6.629	5.970	5.429	4.979	4.597	4.270
4	19.564	14.754	11.841	9.890	8.490	7.438	6.617	5.960	5.421	4.972	4.591	4.265
5	19.460	14.694	11.803	9.863	8.470	7.422	6.605	5.950	5.413	4.965	4.585	4.260
6	19.355	14.634	11.764	9.830	8.450	7.407	6.593	5.940	5.405	4.958	4.580	4.255
7	19.251	14.575	11.726	9.809	8.430	7.392	6.581	5.930	5.397	4.951	4.574	4.250
8	19.150	14.516	11.688	9.783	8.413	7.377	6.569	5.921	5.389	4.945	4.568	4.245
9	19.047	14.457	11.650	9.756	8.392	7.362	6.557	5.911	5.381	4.938	4.562	4.240
10	18.947	14.400	11.613	9.729	8.372	7.346	6.545	5.901	5.373	4.931	4.556	4.235
11	18.848	14.342	11.575	9.703	8.353	7.331	6.533	5.891	5.365	4.924	4.551	4.230
12	18.750	14.285	11.538	9.677	8.334	7.317	6.521	5.882	5.357	4.918	4.545	4.225
13	18.652	14.220	11.501	9.651	8.315	7.302	6.509	5.872	5.349	4.911	4.539	4.220
14	18.556	14.173	11.465	9.625	8.295	7.287	6.498	5.863	5.341	4.904	4.534	4.215
15	18.461	14.118	11.428	9.600	8.276	7.272	6.486	5.853	5.333	4.897	4.528	4.210
16	18.367	14.063	11.392	9.574	8.257	7.258	6.474	5.844	5.325	4.891	4.522	4.206
17	18.274	14.008	11.356	9.549	8.228	7.243	6.463	5.834	5.317	4.884	4.516	4.201
18	18.181	13.953	11.323	9.524	8.219	7.229	6.451	5.825	5.309	4.878	4.511	4.196
19	18.090	13.900	11.285	9.490	8.200	7.214	6.440	5.815	5.301	4.871	4.505	4.191
20	18.000	13.846	11.250	9.473	8.181	7.200	6.428	5.806	5.294	4.864	4.500	4.186
21	17.910	13.793	11.214	9.448	8.163	7.185	6.417	5.797	5.286	4.858	4.494	4.181
22	17.823	13.740	11.180	9.424	8.144	7.171	6.405	5.787	5.278	4.851	4.488	4.176
23	17.734	13.688	11.146	9.399	8.127	7.157	6.394	5.778	5.270	4.845	4.483	4.171
24	17.647	13.636	11.111	9.375	8.108	7.142	6.383	5.769	5.263	4.838	4.477	4.166
25	17.560	13.584	11.077	9.350	8.090	7.128	6.371	5.760	5.255	4.832	4.472	4.161

26	17.475	13.533	11.043	9.326	8.071	7.114	6.360	5.750	5.247	4.825	4.466	4.157
27	17.391	13.483	11.009	9.302	8.053	7.100	6.349	5.741	5.240	4.819	4.460	4.152
28	17.307	13.432	10.975	9.278	8.035	7.086	6.388	5.732	5.232	4.812	4.455	4.147
29	17.225	13.383	10.942	9.254	8.017	7.072	6.327	5.723	5.224	4.806	4.449	4.142
30	17.143	13.333	10.909	9.230	8.000	7.059	6.315	5.714	5.217	4.800	4.444	4.137
31	17.061	13.284	10.876	9.207	7.982	7.045	6.304	5.705	5.210	4.793	4.438	4.133
32	16.981	13.235	10.843	9.183	7.964	7.031	6.293	5.696	5.202	4.787	4.433	4.128
33	16.901	13.186	10.810	9.160	7.947	7.017	6.282	5.687	5.195	4.780	4.428	4.123
34	16.822	13.138	10.778	9.137	7.929	7.004	6.271	5.678	5.187	4.774	4.422	4.118
35	16.744	13.092	10.744	9.113	7.912	6.990	6.260	5.669	5.179	4.769	4.417	4.114
36	16.667	13.043	10.714	9.090	7.895	6.977	6.250	5.660	5.172	4.761	4.411	4.110
37	16.590	12.926	10.682	9.068	7.877	6.963	6.239	5.651	5.164	4.755	4.406	4.105
38	16.514	12.950	10.651	9.044	7.860	6.950	6.228	5.642	5.157	4.749	4.400	4.100
39	16.438	12.903	10.619	9.022	7.843	6.936	6.217	5.633	5.150	4.743	4.395	4.095
40	16.363	12.857	10.588	9.000	7.826	6.923	6.207	5.625	5.142	4.738	4.390	4.090
41	16.289	12.811	10.557	8.977	7.809	6.909	6.196	5.616	5.135	4.730	4.384	4.085
42	16.216	12.766	10.526	8.955	7.792	6.896	6.185	5.607	5.128	4.724	4.379	4.081
43	16.143	12.711	10.495	8.933	7.775	6.883	6.174	5.598	5.121	4.718	4.374	4.077
44	16.071	12.676	10.465	8.911	7.758	6.870	6.164	5.590	5.114	4.712	4.368	4.072
45	16.000	12.631	10.434	8.889	7.741	6.857	6.153	5.581	5.106	4.706	4.363	4.067
46	15.929	12.587	10.404	8.867	7.725	6.844	6.143	5.572	5.099	4.700	4.358	4.063
47	15.859	12.543	10.375	8.845	7.708	6.831	6.132	5.564	5.091	4.693	4.353	4.058
48	15.789	12.500	10.345	8.823	7.692	6.818	6.122	5.555	5.084	4.687	4.347	4.054
49	15.721	12.456	10.315	8.801	7.675	6.805	6.112	5.547	5.077	4.681	4.342	4.049
50	15.652	12.413	10.286	8.780	7.659	6.792	6.101	5.538	5.070	4.675	4.337	4.044
51	15.584	12.371	10.256	8.759	7.643	6.779	6.091	5.530	5.063	4.669	4.332	4.040
52	15.517	12.329	10.227	8.737	7.627	6.766	6.081	5.521	5.051	4.663	4.326	4.035
53	15.450	12.287	10.198	8.716	7.611	6.754	6.071	5.513	5.049	4.657	4.321	4.031
54	15.384	12.245	10.169	8.695	7.595	6.741	6.060	5.504	5.042	4.651	4.316	4.026
55	15.319	12.203	10.140	8.675	7.579	6.739	6.050	5.496	5.035	4.645	4.311	4.022
56	15.254	12.162	10.112	8.654	7.563	6.716	6.040	5.487	5.028	4.639	4.306	4.017
57	15.190	12.121	10.084	8.633	7.547	6.704	6.030	5.479	5.020	4.633	4.301	4.013
58	15.125	12.080	10.055	8.612	7.531	6.601	6.020	5.471	5.013	4.627	4.295	4.008
59	15.062	12.040	10.027	8.591	7.515	6.679	6.010	5.463	5.006	4.621	4.290	4.004

Sea Trials.

To determine the true mean speed of a vessel when the distance run is great.

RULE 1.—Calculate the apparent speed of each run as usual, by dividing the distance by the time, and group them in sets of three: for example, 1, 2, 3; 2, 3, 4; 3, 4, 5; etc.

RULE 2.—Each set of three is to be treated as follows: Find the two intervals of time between the middle instants of the first and second, and of the second and third runs of the set; reduce those intervals to the corresponding angular intervals by the following proportion: As 12 h. 24 m. (the mean duration of a tide) is to a given interval of time, so is 360° to the corresponding angular interval.

RULE 3.—Multiply the *first* apparent speed by the co-secant of the first angular interval; the *second* apparent speed by the sum of the co-tangents of the *two* angular intervals; the *third* apparent speed by the co-secant of the *second* angular interval.

RULE 4.—Add together the products, and divide the sum by the sum of the before-mentioned multipliers; the quotient will be a speed from which tidal effects have been eliminated.

RULE 5.—Add together the velocities deduced from the sets of three runs, and divide by their number for a final mean.

NOTE.—When an interval elapses of more than a quarter of a tide, or 3 h. 6 m., between the middle instant of the two runs of a set, certain multipliers and products must be *subtracted*. The following example will serve to determine whether these certain multipliers are to be taken as positive or negative.

EXAMPLE.

Time.	*Angles.*	*Co-sec.*	*Co-tang.*
Between 0 h. 0 m. and 3 h. 6 m....	Between 0° and 90°......	Positive.	Positive.
" 3 h. 6 m. " 6 h. 12 m....	" 90° " 180°......	"	Negative.
" 6 h. 12 m. " 9 h. 18 m....	" 180° " 270°......	Negative.	Positive.
" 9 h. 18 m. " 24 h. 24 m....	" 270° " 360°......	"	Negative.

REMARKS ON THE TURNING OF SHIPS.

Compiled from Various Sources.

THE curve traversed by a steamer in turning differs very little from a true circle if the evolution is performed in smooth water and light winds. It appears to bring most ships about one breadth of the ship within a true circle when they have turned completely round and regained the course upon which they were steaming when the helm was put over.

The *diameter* of the circle has been found to vary between six and eight times the length of the ship when ordinary rudders have been used with manual power at the wheel.

With balanced rudders the diameter has been reduced to four or five times the length. With steam steering-gear, the diameter has been about four times the length, and with balanced rudders has fallen to three times the length. As the *speed* is reduced the diameter of the circle usually becomes smaller in ships with ordinary rudders and manual power at the wheels, but with balanced rudders or steam-steering, where there is no sensible difference in putting the helm hard over at the different speeds, there is comparatively little difference between the circles turned at full and half speed.

Effect of the Rudder in Turning a Ship.—Suppose a vessel to be advancing on a straight course when the helm is put over. At once there is developed a pressure on the rudder, the magnitude of which increases as the helm angle becomes larger.

This pressure may be resolved into two components, one acting parallel to the keel, and the other acting perpendicularly to it. The latter component is generally the larger, but it has opposed to it the great force of lateral resistance, and can cause but a small angle of drift. The longitudinal component, on the contrary, may exercise considerable effect in checking the speed of the ship.

Finally, when the helm is hard over and held at a constant angle, the ship will be found to be turning in a path which will be nearly a circle, and is sometimes treated as if it were a circle. Her speed will be somewhat less than it would be if she were standing on a straight course with the same engine-power, and her ends will be turning about the vertical axis passing through the centre of gravity, with a nearly uniform angular velocity. An increase in the rudder

area is most influential in diminishing the space traversed in turning; and this decrease may be of great value to a ship intended to act as a ram. This increased area, however, may in some cases check the headway so much as to greatly lengthen the time of completing the circle.

The Most Effective Helm-Angle.—From experiment it is found that, up to 40° at least, increasing the helm-angle gives greater speed of turning, and a smaller diameter of circle.

The time occupied in putting the helm hard over exercises great influence on both the time occupied in turning the circle and its diameter; but more particularly affects the latter.

Effect of Screw.—All single-screw steamers turn more quickly to one side than to the other under similar helm-angles. With well-immersed screws the rule is that the bow turns toward that side to which the descending-blade falls; with light-draught vessels the reverse obtains.

When going astern, the bow of a heavy ship with a left-handed screw will still turn to port; the accepted explanation of this anomaly is that in going ahead, owing to the dead water, the upper blade has more thrust than the lower, having less slip. In going astern, the lower blade has the most effect.

With the same angle of helm and same time occupied in putting the helm hard over, the time of completing the circle appears to vary nearly inversely as the speed.

The following are the published results for the Warrior and Hercules:

WARRIOR.				HERCULES.			
Speeds.	Times of turning circle.		Products of speeds by times.	Speeds.	Times of turning circle.		Products of speeds by times.
	min.	sec.			min.	sec.	
3	28	46	86.3	6	9	32	57.2
6	15	20	93	8	7	21	58.8
9	10	40	96	10	6	22	63.6
12	8	45	105	12⅛	4	28	54.2
14¼	7	21	104.1	14.7	4	0	58.8

The above rule may be used in approximating to the time that will be occupied in turning at any selected speed when the performance at some other speed is known.

Real Path of the Ship.—The path of the ship is found to be a spiral, as in the figure below, and according to Admiral Bourgois, of the French navy, the motion becomes practically uniform when the ship has turned through 90°. According to Mr. White, however, this does not take place until the ship has turned 360°.

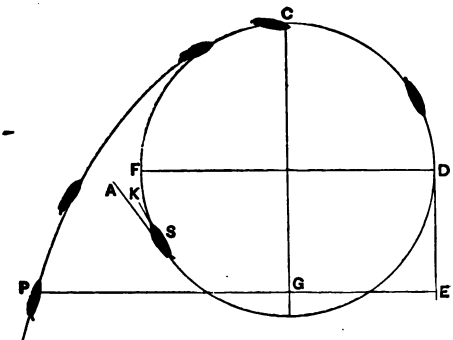


FIG. 1.

The angle A S K is the drift angle.

The following definitions are given by Captain Colomb, of the Royal Navy: In the "circle" P C D F, P is the origin of ordinates on the spot when the helm is put hard down.

P E is the "*tactical diameter*," or the distance between the two courses when the original course is reversed.

C is the point at which a curve of 90° will have been described.

P G and C G will be the co-ordinates of that point.

C G will be the "*advance*," or the distance the ship will have advanced toward an object or shore ahead.

P G will be the "*transfer*," which will be rather more than half the tactical diameter.

F D is the "*final diameter.*" Obviously the tactical diameter, "*advance*" and "*transfer*," are of the highest importance to a ram, and they should be known for every ship. The *drift angle* is the angle between the tangent of the circle and the keel lines of the ship. This drift angle is said to be the principal cause of the decrease of speed, and the rudder pressure has little to do with it.

Owing to the drift angle, it is incorrect to assume that the ship has passed a quarter, half, or whole circle when the ship's head has turned through 90°, 180°, or 360° respectively.

The following table gives the drift angle of the Thunderer with a constant helm angle, but with variations in the speed:

Speed on straight course.	Drift angle.	Diameters of circles (feet).	
		Bow.	Stern.
8.2 knots	5¾	1,350	1,410
94 knots	8¾	1,255	1,345
10.4 knots	9⅛	1,240	1,340
11.14 knots	9¼	1,240	1,340

The Thunderer is a double-screw ship.

The angle of heel is due chiefly to centrifugal force. This angle varies, according to Mr. White.

1. Directly as the square of the speed of the ship.
2. Inversely with the metacentric height.
3. Inversely with the radius of the circle.

The reduction in speed may be taken at three lengths of the ship.

Turning Trials with Twin-screw Vessels.

In turning trials with twin-screw vessels, the following conclusions have been established:

That, with ordinary rudders, such vessels can be steered as efficiently as single-screw ships when both screws are working full speed ahead.

With *balanced* rudders in some ships better performances have been obtained than with sister ships fitted with ordinary rudders.

For example, the Iron Duke, with twin-screws and the ordinary rudder, occupied 4 minutes 37 seconds in completing a circle 505 yards in diameter; her sister ship, the Invincible, with the balanced rudder, occupied 4 minutes and 20 seconds, and turned in a circle 325 yards in diameter. In the case of the Resistance, a single screw ship of the same length and displacement, with an ordinary rudder, 6½ minutes were occupied in turning a circle 600 yards in diameter, and although some part of her slowness in turning may be attributed to her lower speed, her performance on the whole was much inferior to that of the twin-screw vessels.

With the helm amidships, one screw working full speed ahead, and the other full speed astern, the twin-screw vessels can be turned upon their own centres, but the time occupied is considerably greater than when both screws are working ahead and the rudder is used. Again, when the screws are working in opposite directions as before, if the helm is put hard over, the time of turning is generally greater than when both screws are working ahead and the rudder is employed, but less than when the vessels are turned by the action of the screws alone; and the vessels turn nearly upon their centres. For example: The Captain took 5 minutes 24 seconds to complete a circle of 750 yards diameter, with helm hard over, and both screws working full speed ahead, as against 6 minutes 52 seconds with the screws working in opposite directions, when she turned nearly on her centre. When one screw is stopped and the other is worked full speed ahead, with the rudder hard over, vessels can be turned somewhat more slowly than when both screws are working ahead, but the relative diameters of the circles described under the two conditions are undetermined.

With one screw only at work and the helm amidships, the vessel can be turned completely round, but the time of turning and diameter of the circle are both very large. To a vessel of which the rudder and one screw had been damaged, even this turning power might prove of service.

The *shafts*, in twin-screw ships, are commonly placed parallel to one another and to the keel; but it has been suggested that advantage in steering might result from making shafts diverge from one another, in order to increase the leverage of thrust of either propeller about the centre of gravity.

This plan has been adopted in the Faraday, a steamer built for

the purpose of laying telegraph cables, and therefore requiring great handiness under all conditions of wind and sea. It has proved very successful, and it is said that with the rudder locked amidships some of the most delicate operations in laying and splicing cables were performed in a rough sea and strong wind, the ship being manœuvred by the screws alone.

The shafts in this vessel diverge from parallelism with the keel by being at a greater distance from it at their forward ends than at the after ends; abreast of the centre of gravity the distance between the lines of the shafts is about forty feet, while near the propellers the distance is about half as great. Another interesting fact in the management of this vessel is that in order to maintain her position with wind or sea on the beam the two propellers were often worked at different speeds and frequently in opposite directions.

Time and Diameter of Circle of Turning of the Lord Warden at Plymouth, September, 1867.

Speed.	Turning to	Angle of helm.	Time of circle.	Diameter of circle.	Remarks.
		Deg.	M. S.	Feet.	Length of ship, 280 feet.
5	Starboard	25	9 03	1,473	Ordinary rudder and hand-steering gear.
5	Port	25	10 02	1,494	Left-handed four-bladed screw.
5	Starboard	36	8 15	1,179	
5	Port	36	8 53	1,158	
8	Starboard	25	6 16	1,569	
8	Port	25	6 40	1,560	
8	Starboard	36	5 48	1,428	
8	Port	36	5 50	1,242	
12	Starboard	25	5 01	1,668	
12	Port	25	5 07	1,527	
12	Starboard	36	4 26	1,668	
12	Port	36	3 49	1,257	

It will be seen that the diameter of her circle was 4.1 *times her length at a speed of* 5 *knots, and at* 12 *knots speed was* 4.5 *times her length, the times being* 8*m.* 53*s. and* 3*m.* 49*s. respectively.*

In general we may assume the ordinary man-of-war to turn in 4½ times her length at high speed, and a double-screw ship in four times her length.

A Practical Method of Measuring the Circle described by a Ship.

(*F. Martin.*)

The small portable fittings to be used on the occasion are shown in Fig. 2. A is a quadrant with the degrees carefully marked on a piece of wood, which is secured on the ship's rail, with its inner edge, A B, kept parallel to the middle line of the ship; C is a batten about four feet long and three inches broad, with two upright wire sights, S S, one on each end, about eight inches long. The batten is placed on the quadrant with the centre of one end coinciding with the centre of the quadrant, and fixed with a pin through the centre so that it can revolve.

A base (A B, Fig. 3) is set off in a fore-and-aft direction of any convenient length, and at its foremost extremity a straight batten, D, is fixed

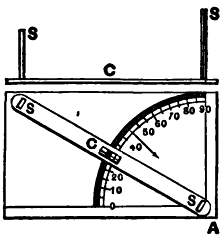


FIG. 2.

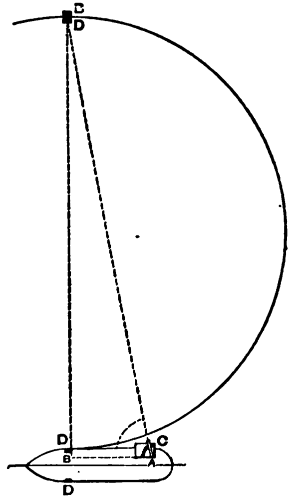


FIG. 3.

vertically to the ship's side, extending a few feet above the rail. The same arrangement is carried out on each side of the ship, and a line joining the edges of the battens D D must be at right angles to the middle line of the ship.

When the helm is hard over, and the ship has fairly commenced her circular course, throw overboard a rough wood box, about a foot square and painted black; as the ship moves onward the box remains nearly stationary on the water, till presently the ship has described a semicircle, which is known by the two battens D D and the box coming into the same straight line. At that instant the batten C is made to revolve till the two wire sights S, S, and the box are in the same straight line; the angle A is then known, being denoted by the batten C on the quadrant. The angle B is a right angle, and the base A B being known, then B O = tangent A × B A, to which must be added twice the breadth of the ship for the greatest space occupied by her in describing the circle. *Example:* If the angle A=80° 15′, and the base B A=90 feet, and the breadth of the vessel =40 feet, then the greatest space occupied by her in describing the circle is $=(90\times 5.81965)+(2\times 40)=603.768$ feet.

WAVES.

Deep Sea Waves.*

MANY attempts have been made to construct a mathematical theory of wave motion, and thence to deduce the probable behavior of ships at sea; and the diversity of these theories affords ample evidence of the difficulties of the subject.

Without attempting any account of the earlier theories, it is proposed to explain the main features of the modern or trochoidal theory for waves.

Let it be supposed that, after a storm has subsided, a voyager in mid-ocean meets with a series of waves all of which are approximately of the same form and dimensions; these would constitute a single series such as the trochoidal theory contemplates.

It is not supposed, however, that an ordinary seaway consists of such a series of waves; on the contrary, more frequently than otherwise, two or more series of waves exist simultaneously, overriding one another, and causing a confused sea, successive waves being of unequal size and varying form. But sometimes the conditions assumed are fulfilled—a well-defined regular series of waves is met

* Portions of these remarks are from the writings of Froude, Rankine, and White. "Transactions of the Institution of Naval Architects."

with; and from the investigation of their motions it is possible to pass to the case of a confused sea.

Any one observing such waves cannot fail to be struck with their rapid advance, even when their dimensions are moderate. A wave 200 feet in length, from hollow to hollow, has a velocity of 19 knots per hour—faster than the fastest steamship—and such waves are of common occurrence. A wave 400 feet in length has a velocity of 27 knots per hour; and an Atlantic storm wave 600 feet long, moves onward at the speed of 32 knots per hour. But in all wave motion it is the *wave form* which travels at these high speeds, and not the

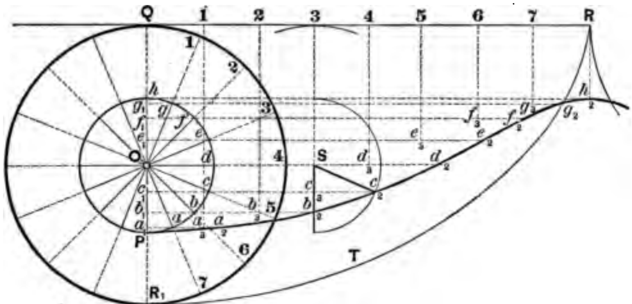


FIG. 4.

particles of water. This assertion is borne out by observation and common experience. If a block of wood is dropped overboard from a ship, past which waves are travelling at great speed, it is well known that it is not swept away, as it would be on a tideway where the particles of water move onward; but it simply sways backward and forward as successive waves pass.

Before explaining this distinction between the motions of the particles in the wave and the motion of the wave form, it will be well to illustrate the mode in which the wave form or profile may be constructed. Fig. 4. will serve the purpose. Suppose Q R to be a straight line, under which the circle whose radius O Q is made to roll.

The length Q R being made equal to the semi-circumference, the rolling circle will have completed half a revolution during its motion from Q to R; and if this length Q R, and the semi-circumference Q R, are each divided into the same number of equal parts (numbered correspondingly 1, 2, 3, etc., in the diagram), then obviously, as the circle rolls, the points with corresponding numbers on the straight line and circle will come into contact successively, each with each. Next suppose a point P to be taken on the radius O R of the rolling circle; this will be termed the "tracing point," and as the circle rolls, the point P will trace a curve (a trochoid, marked P, a_2, b_2, c_2 . . . h_2 in the diagram), which is the theoretical wave profile from hollow to crest, P marking the hollow and h_2 the crest.

The trochoid may, therefore, be popularly described as the curve traced on a vertical wall by a marking-point fixed in one of the spokes of a wheel, when the wheel is made to run along a level piece of ground at the foot of the wall; but when thus described, it would be inverted from the position shown in Fig. 4. To determine a point on the trochoid is very simple. As the rolling circle advances, a point on its circumference (say 3) comes into contact with the corresponding point of the directrix-line Q R, the centre of the circles must at that instant be (S) vertically below the point of contact (3) and the angle through which the circular disk and the tracing-arm O P have both turned is given by Q O 3. The angle P O c on the original position of the circles equals Q O 3; through S draw Sc_2 parallel to O c, and make S c_2 equal to Oc; then c_2 is a point on the trochoid. Or, the same result may be reached by drawing c c_3 horizontal, finding its intersection (c_3) with the vertical line S 3, and then making C c_2 C_3 equal to c c_1.

The tracing-arm (O P) may, for wave-motion, have any value not greater than the radius of the rolling-circle (O Q).

If O P equals O Q, and the tracing-point lies on the circumference of the rolling-circle, the curve traced is termed a *cycloid*, and corresponds to a wave on the point of breaking. The curve R T R in Fig. 4 shows a cycloid, and it will be noticed that the crest is a sharp ridge or line (at R), while the hollow is a very flat curve.

A few definitions must now be given of terms that will be frequently used hereafter. The *length* of wave is its measurement from crest to crest, or hollow to hollow—Q R would be the half-*length*. The *height* of a wave is reckoned from hollow to crest;

thus, for the trochoidal wave, the height would be P h—twice the tracing-arm. The *period* of a wave is the time (usually in seconds) its crest or hollow occupies in traversing a distance equal to its own length; and the velocity (in feet per second) will, of course, be obtained by finding the quotient of the length divided by the period, and would commonly be determined by noting the speed of advance of the wave-crest.

Accepting the condition that the profile of an ocean wave is a trochoid, the motion of the particles of water in the wave requires to be noticed; and it is here the explanation is found of the rapid advance of the wave-form, while individual particles have little or no advance. The trochoidal theory teaches that every particle revolves with uniform speed in a circular orbit (situated in a vertical

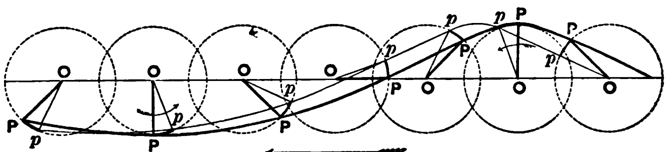


FIG. 5.

plane which is perpendicular to the wave-ridge), and completes a revolution during the period in which the wave advances through its own length. In Fig. 5, suppose P, P, P, etc., to be particles on the upper surface, their orbits being the equal circles shown: then for this position of the wave the radii of the orbits are indicated by O P, O P, etc.

The arrow below the wave-profile indicates that it is advancing from right to left; the short arrows on the circular orbits show that at the wave-crest the particle is moving in the same direction as the wave is advancing in, while at the hollow the particle is moving in the opposite direction.

Now, suppose all the tracing-arms, O P, O P, etc., to turn through the equal angles, P O p, P O p, etc.; then the points, p, p, p, etc., must be corresponding *positions of* particles on the surface formerly situ-

ated at P, P, P, etc. The curve drawn through *p*, *p*, *p*, etc., will be a trochoid identical in form with P, P, P, etc., only it will have its crest and hollow further to the left; and this is a motion of advance in the wave-form produced by simple revolution of the tracing-arms and particles (P). The motion of the particles in the direction of advance is limited by the diameter of their orbits, and they sway to and fro about the centres of the orbits. Hence it becomes obvious why a log dropped overboard, as described above, does not travel away on the wave upon which it falls, but simply sways backward and forward. One other point respecting the orbital motion of the particles is noteworthy. This motion may be regarded at every instant as the resultant of two motions—one vertical, the other horizontal—except in four positions, viz.: (1) when the particle is on the wave-crest; (2) when it is in the wave-hollow; (3) when it is at mid-height on one side of its orbit; (4) when it is at the corresponding position on the other side.

On the crest or hollow the particle instantaneously moves horizontally, and has no vertical motion.

At mid-height it moves vertically, and has no horizontal motion. Its maximum horizontal velocity will be at the crest or hollow; its maximum vertical velocity at mid-height. Hence, uniform motion along the circular orbit is accompanied by accelerations and retardations of the component velocities in the horizontal and vertical directions.

The particles which lie upon the trochoidal upper surface of the wave are situated in the level surface of the water when at rest. The disturbance caused by the passage of the wave must extend far below the surface, affecting a great mass of water. But at some depth, supposing the depth of the sea to be very great, the disturbance will have practically ceased; that is to say, still, undisturbed water may be conceived as underlying the water forming the wave; and reckoning downward from the surface, the extent of disturbance must decrease according to some law. The trochoidal theory expresses the law of decrease, and enables the whole of the internal structure of a wave to be illustrated in the manner shown in Fig. 6.

On the right-hand side of the line A D the horizontal lines marked 0, 1, 2, 3, etc., show the positions in still water of a series of particles which during the wave transit assume the trochoidal forms numbered respectively 0, 1, 2, 3, etc., to the left of A D. For still

water every unit of area in the same horizontal plane has to sustain the same pressure; hence a horizontal plane would be termed a sur-

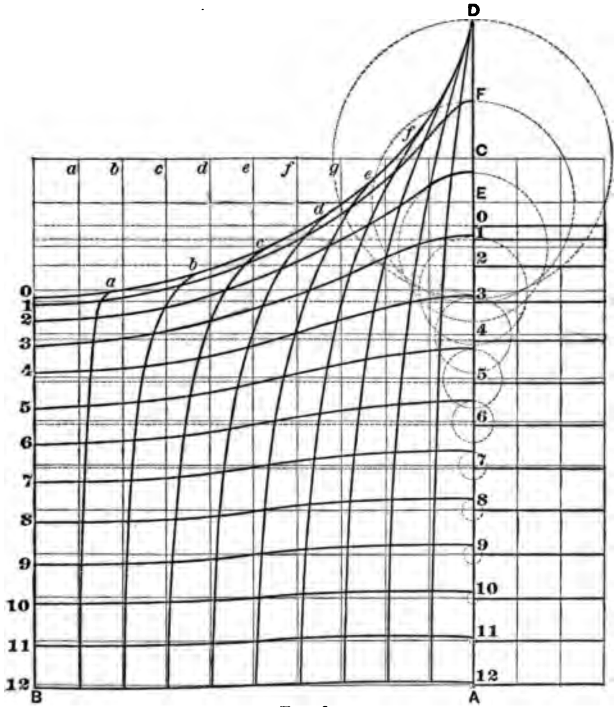


FIG. 6.

face or subsurface of "equal pressure" when the water is at rest. As the *wave passes*, the trochoidal surfaces corresponding to that

horizontal plane will continue to be a subsurface of equal pressure; and the particles lying between any two planes (say 6 and 7) in still water will, in the wave, be found lying between the corresponding trochoidal surfaces (6 and 7).

In Fig. 6 it will be noticed that the level of the still-water surface (0) is supposed changed to a cycloidal wave, the construction of which has already been explained; this is the limiting height the wave could reach without breaking.

The half-length of the wave A B being called L, the radius (C D) of the orbits of the surface-particles will be given by the equation

$$C\,D = R = \frac{L}{\pi} = \frac{7}{22}\,L \text{ (nearly).}$$

All the trochoidal surfaces have the same length as the cycloidal surface, and consequently they are all generated by the motion of a rolling circle or radius, R; but their tracing-arms—measuring half the heights from hollow to crest—rapidly decrease with the depth (as shown by the dotted circles), the trochoids becoming flatter and flatter in consequence. The crests and hollows of all the subsurfaces are vertically below the crest and hollow of the upper wave profile. The heights of these subsurfaces diminish in a geometrical progression; and the following approximate rule by Professor Rankine is very nearly correct. "The orbits and velocities of the particles of water are diminished by *one-half*, for each additional depth below the mid-height of surface wave equal to *one-ninth* of a wave length." For example—

Depths in fractions of a wave-length below the mid-height of the surface wave—0, $\frac{1}{9}$, $\frac{2}{9}$, $\frac{3}{9}$, $\frac{4}{9}$, etc.

Proportionate velocities and diameters—1, $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{16}$, etc.

Take an ocean storm-wave 600 feet long and 40 feet high from hollow to crest: at a depth 200 feet below the surface ($\frac{3}{9}$ of length) the subsurface trochoid would have a height of 5 feet; at a depth of 400 feet ($\frac{6}{9}$ of length) the height of the trochoid—measuring the diameter of the orbits of the particles there—would be about seven or eight inches only; and the curvature would be practically insensible on the length of 600 feet.

It will be noticed also that the centres of the tracing circles corresponding to any trochoidal surface lie above the still-water level of the corresponding horizontal plane. Take the horizontal plane (1),

for instance. The height of the centre of the tracing circle for the corresponding trochoid is marked E, E F being the radius; and the point E is some distance above the level of the horizontal line. Suppose r to be the radius of the orbits for the trochoid under consideration, and R the radius of the rolling circle, then the centre of the tracing circle will be above the level line by a distance equal to $\frac{r^2}{2R}$. Now R is known when the length of the wave is known; also r is given for any depth by the above approximate rule. Consequently the means are at hand for drawing the series of trochoidal subsurfaces for any chosen wave.

Columns of particles which are vertical in still water become curved during the wave passage; in Fig. 6 a series of such lines is drawn (*fine* lines *a*, *b*, *c*, *d*, etc.); during the wave transit these lines assume the positions shown by the strong lines (*a*, *b*, *c*, *d*, etc.) curving toward the wave-crest at their upper ends, but still continuing to inclose between any two the same particles as were inclosed by the corresponding lines in still water. The rectangular spaces inclosed by these vertical lines and the level lines produced are changed during the motion into rhomboidal-shaped figures, but remain unchanged in area.

The maximum slope of the wave to the horizon occurs at a point nearer the crest than the hollow, but no great error is assumed in supposing it to be at mid-height in ordinary ocean waves where the radius of the tracing arm (or half-height of wave) is about one-twentieth of the length. For this maximum slope we have sine of angle $= \frac{\text{radius of tracing circle}}{\text{radius of rolling circle}} = \frac{\text{half height of wave}}{\text{length of wave} \div 6.282} = 3.1416 \times \frac{\text{height of wave}}{\text{length of wave}}$. For waves of ordinary steepness all practical purposes are served by writing the circular measure of the angle instead of the sine; hence approximate maximum wave slope (in degrees) $= 180° \times \frac{\text{height of wave}}{\text{length of wave}}$.

As an example, take a wave for which the dimensions were actually determined, 180 feet long and 7 feet high: Maximum slope $= 180° \times \frac{7}{180} = 7°$ (nearly). The variation in the direction of the normal was in this case equivalent to an oscillation of a pendulum swing-

ing 7° on either side of the vertical once in every half-period of the wave—some three seconds

Shallow Water Waves.

In shallow water of uniform depth the orbit of each particle is an oval, the orbits becoming more flattened the nearer the particles are to the bottom. As an approximation, water may be taken as *shallow* when the depth is between $\frac{6}{12}$ and $\frac{1}{30}$ of a wave length.

Method of Observing the Dimensions and Periods of Waves.

(*Froude.*)

The method of observation to be adopted on board a ship for the purpose of determining the periods and dimensions of waves will naturally be somewhat different according as the ship is stationary or in motion. If she be stationary, the wave *period* may be at once determined by a single observer, noting the moment at which successive wave-crests pass the particular part of the ship on which he stands.

In describing the observations by which tho *length* of wave is to be determined, it is convenient to assume first that the ship is "end on" to the wave-crests.

If the length of the wave be less than that of the ship, two observers should watch two consecutive wave-crests which are rolling past the ship; and each should simultaneously, on the word being given, notice the position on the ship's side occupied by the wave he is watching. The interval between the positions measured on the ship's deck is the wave-length.

If the length of the wave be greater than the ship's length the process is less simple.

Let a convenient length be set off along the deck; and at each end of the line, transversely to it, let a pair of battens be erected so as to define a pair of parallel lines at right angles to the ship's keel; and let an observer be stationed at each, say No. 1 at the end of the line which the waves first meet, No. 2 at the other.

Let observer No. 1 note the instant of time when a wave-crest *passes* the line of sight marked by his pair of battens; and let No. 2

note it when the same wave-crest passes the line marked by his; and let the observation be repeated for the succeeding wave-crest by one of the observers. This latter observation fixes the *period* of the wave, as has already been mentioned.

If the times noted by the two observers be compared, the difference will give the time occupied by the wave-crest in passing the interval between the two parallels. The time occupied by the crest in passing this known interval defines the *speed* of the wave.

The period being known, and the speed being known, the *length* may be deduced, since it is the distance which the wave having that speed will traverse in the period.

If the ship be not end on to the waves, but deviate from that position by a known angle, the values of the speed and length of wave thus deduced, will be alike too great, but they will give the true values when multiplied by the cosine of the deviation.

If the ship be not stationary, but moving with a known speed, it is convenient to assume, as before, that she is end on to the waves, so that she is either running before the sea or is heading it.

Under these circumstances the same observations are to be made, but the period, speed, and length deduced from them require the following corrections:

The time which elapses between the transits of two consecutive wave-crests past either observer is greater or less than the true period, because the distance actually travelled by the wave during the time is greater or less than the true wave-length by the distance travelled in the mean time by the ship, either *from* the waves or *toward* the waves. But as the speed of the ship is known, the *true* speed of the wave may be inferred from its *apparent* speed as deduced from the observations, by adding to it or deducting from it the speed of the ship according as she is running before the waves or heading them; and by help of this correction the true wave-length and period may be readily found.

If the course of the ship be not on a line at right angles to the wave-crest, but deviate from it by a given angle, the same observations must be made, and these must be treated in the same manner as if the course had not been oblique.

And here, also, the apparent length and speed deduced will be too great, but will yield the true values when multiplied by the cosine of the deviation.

Wave-heights are less easy to determine by ordinary observation. But when they are such that if a ship is in the trough of the sea the nearest wave-crests hide the distant horizon from the eye of an observer on deck, he may, by ascending the rigging, place himself at such a height that the successive ridge levels, as viewed by him from the trough, just reach the line of the horizon. And if he measures the height of his eye above the water, that height is the height of the wave.

It must be borne in mind that in pitching and 'scending the head or stern of the ship, when the wave-hollow passes it, is often immersed far deeper than the natural water line, and the observer must make due allowance for this if he be stationed forward or aft; and though by posting himself in the ship's waist he will avoid the necessity of so large a correction, yet even thus, when a ship end on to the waves is in the middle of the trough, the curvature of the wave-hollow gives extra immersion to her ends, and the water surface amidships is below her natural water line. Due allowance must also be made for changes of level occasioned by rolling or keeling. Other methods of observing the dimensions of waves have been devised and used; some of them being automatic in their action, and giving a continuous record of the heights of the wave profile at every instant upon the scale of measurement.

When the waves are not high enough to use the method of horizon observation, it is necessary that any other method of measuring heights should refer them in some manner to the level of the practically still water underlying the water disturbed by wave motion.

Dimensions of Waves.—The longest wave observed was measured by Captain Mottez, of the French navy, in the North Atlantic, and had a length of 2,720 feet—half a mile from crest to crest; its period was 23 seconds. In the South Atlantic Sir James Rose observed a wave 1,920 feet long. The largest waves observed in European waters have had a period of 19¾ seconds, corresponding to a length of some 2,000 feet; in the Bay of Biscay waves have been noted having a length of 1,320 feet. Dr. Scoresby's Atlantic storm waves had lengths of about 500 to 600 feet, and periods from 10 to 11 seconds. According to the best authorities ocean waves of 24 seconds' period and 3,000 feet in length may be taken as the *extreme limit* of size yet proved to exist; waves of 18 seconds'

period and about 1,650 feet in length constitute the upper limit in all except extraordinary cases; and what may be called ordinary large storm waves have periods varying from 6 to 9 seconds, the corresponding lengths varying from 200 to 400 feet.

Turning to heights, we find reports of heights of 100 feet from hollow to crest, but no verified measurement exists of a height half as great as this. The highest reliable measurements are from 44 to 48 feet—in itself a very remarkable height. Waves having a greater height than 30 feet are not often encountered.

Next as to the ratio of the heights to the lengths observed in deep-sea waves. Authorities agree that as the lengths increase this ratio diminishes, and the wave-slope becomes less steep. The shortest waves are the steepest; and the greatest recorded inclinations are for very short waves, when the ratio of height to length was about 1 to 6. For a cycloidal wave the ratio is about 1 to 3.14; so that in the steepest sea waves observed this ratio is only about one-half that of the theoretical limiting case.

For waves from 330 to 350 feet in length, the ratio of 1 to 8 has been observed, but these were exceptionally steep waves; for waves of 500 to 600 feet in length it falls to about 1 to 20; and for the longest waves it is said to fall as low as 1 to 50.

It seems probable that in waves of the largest size commonly met, the height does not exceed one-twentieth of the length; and the higher limit of steepness in waves which are large enough to considerably influence the behavior of ships does not give a ratio of height exceeding 1 to 10. Waves from 500 to 900 feet in length are sometimes encountered, having heights of from 5 to 10 feet only.

Formulæ.

The principal formulæ for lengths, speeds, and periods for trochoidal waves are as follows:

I. Length (in feet) $= 5.123 \times$ square of period (in seconds) $= 5\frac{1}{8} \times$ square of period.

II. Speed $\left(\begin{matrix}\text{in feet}\\\text{per second}\end{matrix}\right) = 5.123 \times \text{period} = \sqrt{5.123 \times \text{length}} = 2\frac{1}{4}\sqrt{\text{length}}$.

33

III. Speed $\left(\begin{matrix}\text{in knots}\\ \text{per hour}\end{matrix}\right) = 3 \times$ period (roughly).

IV. Period (in seconds) $= \sqrt{\dfrac{\text{length}}{5.123}} = \frac{4}{9}\ \sqrt{\text{length}}.$

V. $\left.\begin{matrix}\text{Orbital velocity of}\\ \text{particles on surface}\end{matrix}\right\} = \left\{\begin{matrix}\text{speed of}\\ \text{wave}\end{matrix}\right\} \times \dfrac{3.1416 \times \text{height}}{\text{length}} = 7\frac{1}{9} \times \dfrac{\text{height}}{\sqrt{\text{length}}}.$

Take the case of a wave 400 feet long and 15 feet high. For it we obtain, Period $= \frac{4}{9}\ \sqrt{400} = 8\frac{8}{9}$ seconds.

Speed $= 2\frac{1}{4}\ \sqrt{400} = 45$ feet per second $= 3 \times 8\frac{8}{9} = 26\frac{2}{3}$ knots per hour.

Orbital velocity of surface particles $= 7\frac{1}{9} \times \dfrac{15}{\sqrt{400}} = 5\frac{1}{3}$ feet per second.

Table of Periods.

The periods of waves are most easily observed, and the following table will be useful as giving the lengths and speeds of trochoidal waves for which the periods are known :

PERIOD.	LENGTH.	SPEED OF ADVANCE.		PERIOD.	LENGTH.	SPEED OF ADVANCE.	
Seconds.	Feet.	Feet per second.	Knots per hour.	Seconds.	Feet.	Feet per second.	Knots per hour.
1	5.12	5.12	3.03	9	414.99	46.11	27.31
2	20.49	10.24	6.07	10	512.33	51.23	30.35
3	46.11	15.37	9.1	11	619.92	56.36	33.38
4	81.97	20.49	12.14	12	737.76	61.48	36.42
5	128.08	25.62	15.17	13	865.84	66.6	39.45
6	184.44	30.74	18.21	14	1004.17	71.73	42.49
7	251.04	35.86	21.24	15	1152.74	76.85	45.52
8	327.89	40.99	24.28	16	1311.56	81.97	48.56

METHODS OF OBSERVING THE ROLLING AND PITCHING MOTIONS OF SHIPS.

(*W. H. White.*)

THE most important methods which have been adopted for observing the rolling and pitching of ships are as follows:

1. The use of pendulums, with various forms of clinometers; these pendulums having periods of oscillation which are very short as compared with the periods of the ships.
2. The use of gyroscopic apparatus.
3. The use of "batten" instruments.

PENDULUMS, or clinometers, are not trustworthy indicators of the angles of inclination attained by a ship when rolling in still water, and much less of those moved through by a ship rolling or pitching at sea. When a ship is held at a steady angle of heel, a pendulum suspended in her will hang vertically, no matter where its point of suspension may be placed, and will indicate the angle of heel correctly. The only force then acting upon the pendulum is its weight, *i. e.*, the directive force of gravity, the line of action being vertical.

But when instead of being steadily inclined the ship is made to oscillate in still water, she will turn about an axis passing through or very near to the centre of gravity; hence every point not lying in the axis of rotation will be subjected to angular accelerations. Supposing the point of suspension of the clinometer to be either above or below the axis of rotation, it will be subjected to these accelerating forces as well as to the directive force of gravity, and at each instant instead of placing itself vertically, the pendulum will tend to assume a position determined by the resultant of gravity and the accelerating force. We have therefore this valuable practical rule:

When a ship is rolling in still water, if a pendulum is used to note the angles of inclination, it should be hung at the height of the centre of gravity of the ship; for if hung above or below that position, it will indicate greater angles than are really rolled through, the error of the indications increasing with the distance of the point of suspension from the axis of rotation and the rapidity of the rolling motion of the ship.

When we turn to the more complicated case of a ship oscillating amongst waves, there are good reasons for supposing that the errors

of pendulum observations will be exaggerated. The centre of gravity of the ship is then subjected to the action of horizontal and vertical accelerating forces. If the pendulum were hung at the centre of gravity of the ship, it would therefore no longer maintain a truly vertical position during the oscillations, but would assume at each instant a position determined by the resultant of the accelerating forces and of gravity. The direction of this resultant has been found to coincide with that of the corresponding normal to the effective wave slope. Hence another useful, practical rule:

When a ship is rolling amongst waves, a quick-moving pendulum suspended at the height of the centre of gravity will place itself normal to the effective wave-slope, and its indications will mark the successive inclinations of the masts of the ship to that normal, not their inclinations to the true vertical.

When hung at any other height than that of the centre of gravity of a ship rolling amongst waves, the indications of a pendulum are still less to be trusted.

NOTE.—*It may be proper to add, that any other devices, such as spirit-levels, depending for their action on the directive force of gravity, or statical conditions, are affected by the motion of a ship as much as a pendulum is affected.*

Several kinds of GYROSCOPIC INSTRUMENTS have been devised for the purpose of measuring rolling and pitching motions, all of them being based upon the well-known principle, that a delicately balanced heavy-rimmed wheel, spinning rapidly, will maintain the plane of rotation in which it is set spinning, until its speed of rotation is considerably diminished.

One great defect of all gyroscopic instruments, however, is that there is no separate indication of the angles of inclination attained on either side of the vertical. As a ship in a seaway changes its position rapidly, it is practically impossible to secure the condition of initial horizontality; hence the observer must be content to note the *total arcs* of oscillation. No doubt, in most cases, the rolling of a ship not under sail approaches equal inclinations on either side of the vertical, the roll to leeward being somewhat in excess of that to windward; but in a ship under sail the rolling takes place about an inclined position, and in any case it is a great advantage to be able to ascertain the extreme inclination on either side of the vertical.

BATTEN INSTRUMENTS afford the simplest correct means of ob-

serving the oscillations of ships; they can be employed whenever the horizon can be sighted. The line of sight from the eye of an observer standing on the deck of a ship to the distant horizon will always remain practically horizontal during the motion of the ship. Consequently if a certain position be chosen at which the eye of the observer will always be placed, and when the ship is upright and at rest, the horizontal line passing through that point is determined and marked in some way; this horizontal line can be used as a line of reference when the ship is rolling or pitching, and the angle it makes at any instant with the line of sight will indicate the inclination of her masts to the vertical.

The principle may be applied in different ways; one of the most common is illustrated below. The point E on the middle line of the cross section marks the position of the eye of the observer; and at equal distances athwart ship, two battens, C C and G G, are fixed perpendicularly to the deck, so that when the ship is upright and at rest, these battens are vertical, and at that time the line F E F will be horizontal. This line may be termed "zero-line;" and the points F F would be marked upon the battens, being at a height above the deck exceeding that of the point E by an amount determined by the

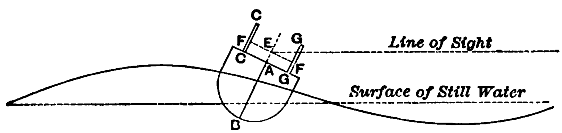


FIG. 7.

"round" of the deck. Suppose the diagram to represent the case of a ship rolling among waves; when she has reached the extreme of an oscillation to starboard, E G marks the line of sight to the horizon, and the angle G E F measures the angle of inclination of the masts to the vertical. If the battens are placed longitudinally, instead of transversely, the angular extent of pitching may be similarly measured.

It is a great practical advantage to have the vertical battens graduated so that an observer can at once read off and note down the angles of inclination in degrees. Once graduated, the battens

can be removed when the observations are not in progress, and replaced in the same positions when required.

In graduating battens, the following table of tangents from 1° to 40° may be of service:

Angles.	Tangents.	Angles.	Tangents.	Angles.	Tangents.
Deg.		Deg.		Deg.	
1	0.017	15	0.268	29	0.554
2	0.035	16	0.287	30	0.577
3	0.052	17	0.306	31	0.601
4	0.07	18	0.325	32	0.625
5	0.087	19	0.344	33	0.649
6	0.105	20	0.364	34	0.675
7	0.123	21	0.384	35	0.7
8	0.141	22	0.404	36	0.727
9	0.158	23	0.424	37	0.754
10	0.176	24	0.445	38	0.781
11	0.194	25	0.466	39	0.81
12	0.218	26	0.488	40	0.839
13	0.231	27	0.51		
14	0.249	28	0.532		

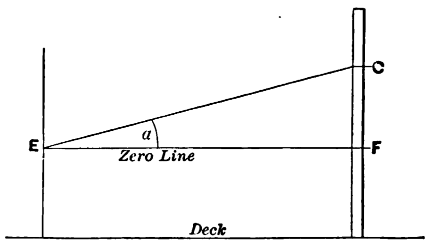


FIG. 8.

The zero-line on the battens having been fixed, the horizontal distance from the position where the eye of the observer will be placed to the vertical batten is measured; suppose this to be d feet, it will be indicated by E F in Figs. 7 and 8. Then for any angle, a, we have:

Vertical height, F G, to be set off above zero-line on battens $= d$ *tangent* a.

The value of tangent a being taken from the table, the product d tangent a can be found.

For instance, suppose $d=20$ feet, and $a=15°$: tangent $a=0.268$, and vertical distance, F G, to be set off above zero-line will be $(20 \times 0.268)=5.36$ feet.

With this table and the example of its use, the very simple process of graduation can present no difficulty.

The proper conduct of observations with batten instruments requires at least two observers: one to note the extreme angles of inclination attained by the ship, a second to note the periods of successive rolls.

In the English Navy, a single series of observations would last ten minutes, and during that time an observer would have to note the extreme inclinations for from seventy to, perhaps, one hundred and fifty or two hundred single rolls, according to the class of ship and character of the waves. The other observer would, meanwhile, note the times of performing successive rolls, and the total number of rolls during the ten minutes.

To complete the materials required for a discussion of the behavior of the ship, the dimensions and periods of the waves ought to be observed simultaneously with the rolling or pitching; and this requires the attention of an independent set of observers.*

Whatever method of observing the rolling or pitching may be adopted, the observations made cannot have their full value unless the attendant circumstances are fully recorded. For example: *the actual condition of the ship* should be noted; whether under sail or steam; what portion of her stores remain on board; whether there is any water in the bilges; and any other features that would affect the period of oscillation. Her *course* and *speed* should also be stated, the former being given relatively to the wave advance, and the angle between the two being stated in degrees. The dimensions and periods of the waves should also be carefully determined.

No change should be made affecting the behavior of the ship for at least ten minutes before the observations are commenced.

---

* *More complete information, such as is most valuable for scientific purposes, can be best obtained by means of automatic instruments, the records of which may be made continuously during prolonged periods.*

THE DISPLACEMENT AND BUOYANCY OF SHIPS.

("*Manual of Naval Architecture.*")

A SHIP floating at rest in still water must displace a volume of water having a weight equal to her own weight.

Ships which are of equal weight may differ greatly in form and dimensions, and consequently the forms of their respective displacements will differ, but when they are floating in water of the same density the volumes must be equal to one another, because the weights of the ships are equal. On the other hand, when a ship passes from water of one density to water of another density—say from the open sea to a river where the water is comparatively fresh—her volume of displacement must change, because the weight of water displaced must be the same in both cases. Under all circumstances, the volume of displacement multiplied by the weight per unit of volume of the water in which the ship floats, must equal the weight of the ship. It is usual to express the volume in cubic feet, and for sea-water to take sixty-four pounds as the weight of a cubic foot, so that the weight of the ship in tons multiplied by thirty-five, gives the number of cubic feet in the volume of displacement when she floats in sea-water.

At every point on the bottom of a ship afloat, the water-pressure acts perpendicularly to the bottom. This normal pressure depends upon the depth of the point below the surface; and it may be regarded as made up of three component pressures. First, a vertical pressure; second, a horizontal pressure acting athwart ship; third, a horizontal pressure acting longitudinally.

The horizontal components in each set must obviously be exactly balanced amongst themselves, otherwise the ship would be set in motion. The sum of the vertical components must be balanced by the weight of the ship, which is the only other vertical force; this sum is termed "buoyancy." It equals the weight of water displaced, and the two terms, "buoyancy" and "displacement," are often used interchangeably.

The total weight of a ship may be subdivided into the "weight of the hull" and the "weight of lading." The latter measures the "carrying power of the ship," and is frequently termed the "useful displacement."

Useful displacement for a certain degree of immersion is simply the difference between the total displacement and the weight of the hull; so that any decrease in the weight of hull leads to an increase in the carrying-power.

Having given the draught of water to which it is proposed to immerse a ship, the volume of her immersed part determines the corresponding displacement, which can be calculated with exactitude from the drawings of the ship. This is the method adopted by the naval architect; but an estimate may be rapidly made by the following rule.

Approximate Rule for Displacement.—Assuming that the length of the ship on the load-line is known, also the breadth, extreme and mean draught, the product of these three dimensions will give the volume of a parallelopipedon circumscribing the immersed portion of the ship. This may be written : Volume of parallelopipedon $= V$ (cubic feet) $= L \times B \times D$. The volume of displacement may then be expressed as a *percentage* of V; and for the undermentioned classes of ships the following rules hold :

Classes of ships.	Displacement equal to percentage of volume V.
Fast steam-ships,	43 to 46 per cent.
Swift steam-cruisers, corvettes, sloops,	46 to 52 "
Gun-vessels, merchant steamers (common forms),	55 to 60 "
Modern types of iron-clads,	60 to 62 "
Mastless sea-going iron-clads, / Cargo-carrying steamers of moderate speed,	65 to 70 "

The percentages stated are technically known as "coefficients of fineness," expressing, as they do, the extent to which the immersed part of the ship is "fined" or reduced from the parallelopipedon that can be circumscribed about it.

Ships vary in their draught of water and displacement as the weights on board vary, and in cargo-carrying merchantmen this variation is most considerable, their displacement without cargo, coal, or stores, often being considerably less than one-half of the load-displacement. In ships of war the variation in displacement is not usually so great; but even in them the aggregate of consumable stores reaches a large amount, and when they are out of the ship she may float two or three feet lighter than when fully laden.

Curve of Displacement.—Naval architects have devised a plan by which, without performing a calculation for every line at which a ship may float, it is possible to ascertain the corresponding displacement by a simple measurement. Fig. 9 illustrates one of the

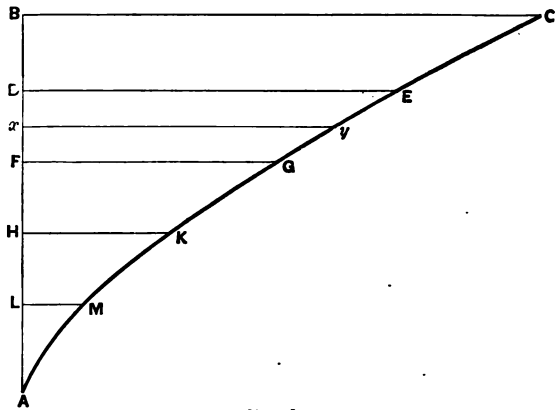


FIG. 9.

"curves of displacement" drawn for this purpose. It is constructed as follows:

The displacements up to several water-lines are obtained by direct calculation from the drawings of the ship in the manner before mentioned. Then a line, A B, is drawn, the point, A, representing the under side of the keel, and the length, A B, representing the "mean draught" of the ship when fully laden, this mean draught being half the sum of the draughts of water forward and aft. Through B a line, B C, is drawn at right angles to A B, the length, B C, being made to represent, to scale, the total displacement of the ship when fully laden: an inch in length along B C representing, say, one hundred tons of displacement. Suppose the displacement *to have* been also calculated up to another water-line (represented by *D E in the* diagram) parallel to and at a known distance below the

load-line B C. Then on D E a length is set off representing this second displacement, on the same scale as was used for B C. Similarly the lengths, F G, H K, and so on, are determined, and finally the curve C E G . . . . A is drawn through the ends of the various ordinates.

When this curve is once drawn it becomes available to find the approximate displacement for any draught of water at which the ship may float, supposing that she does not very greatly depart in *trim* from that at which she floats when fully laden. For instance, suppose the mean draught for which the displacement is required to be four feet lighter than the load-draught. Set down B x, representing the four feet, on the same scale on which A B represents the load-draught. Through x draw x y perpendicular to A B to meet the curve, and the length x y (on the proper scale) measures the displacement at the light draught.

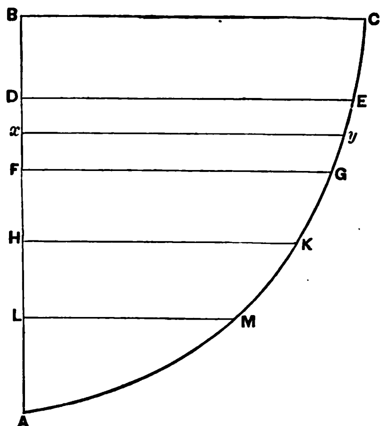


FIG. 10.

Curve of Tons per Inch Immersion.—Another problem that frequently occurs, is the determination of the increased immersion which

will result from putting a certain weight on board a ship when floating at a known draught, or the decreased immersion consequent on removing certain weights. The diagram, Fig. 10, represents a "curve of tons per inch immersion;" the horizontal measurement from the base-line A B representing (on a certain scale) the number of tons which would immerse the ship one inch when she is floating at the draught corresponding to the ordinate along which the measurement is made. The construction of this curve is very similar to that of the curve of displacement, the successive points on the curve being found for the equi-distant water-lines B C, D E, F G, etc., by direct calculation from the drawings of the ship; and the length of the ordinate xy determining the number of tons required to immerse the ship one inch when floating at any mean draught, A x. In this case also it is to be understood that at the various draughts considered there are no considerable departures in trim from that of the fully laden ship.

For all practical purposes no great error is involved in assuming that twelve times the weight which would sink the ship one inch below her load-line will sink her one foot, or that a similar rule holds for the same extent of lightening from the load-draught.

Practical Rule for Tons per Inch Immersion.—Using the same symbols as before, viz.: Length of ship at load-line = L; breadth = B; we should have area of circumscribing parallelogram = L × B = A (square feet). And then the following rules express, with a considerable amount of accuracy, the number of tons required to immerse the ship one inch when floating at her load-draught:

	Tons per Inch.
1. For long fine ships of great speed, ...	$= \frac{1}{600} \times A.$
2. For ships of ordinary form (including the majority of vessels), ...	$= \frac{1}{560} \times A.$
3. For ships of great beam in proportion to length (say less than five beams in length) . . .	$= \frac{1}{500} \times A.$

The Trenton comes under rule 2, being of ordinary form. Her dimensions are: Length = 253 feet; breadth = 48 feet; Area of circumscribing parallelogram = A = 12,144 square feet. ∴ Tons per inch at load-line $= \frac{1}{560} \times 12{,}144 = 21\frac{2}{3}$ tons. It is easy to see *how* the curves of tons per inch, and the curves of displacement *constructed* for the case of ships floating in sea-water, may be made

use of in order to determine the change of draught produced by the passage of a ship into a river or dock where the water is comparatively fresh. For example, sea-water weighs sixty-four pounds per cubic foot, whereas in one of the London docks the water weighs about sixty-three pounds per cubic foot, or one-sixty-fourth part less than sea-water. Since the total *weight* of water displaced by the ship must remain constant, it is only necessary to make the following corrections: *Difference between weights of sea-water and river-water for the volume immersed up to the draught at which the ship floats at sea* $= \frac{1}{64} \times$ weight of ship $= \frac{1}{64}$ W.

Tons per inch immersion at this draught in river $= \frac{63}{64}$ *ton per inch for sea-water* $\frac{63}{64}$ T.

∴ Increase in draught of water when ship floats in river-water $= \frac{1}{64} \times \mathrm{W} \div \frac{63}{64}\mathrm{T} = \dfrac{\mathrm{W}}{63\,\mathrm{T}}$ (inches).

For any other density of water than that assumed above, the correction would be made in a similar manner.

The draught being observed when the vessel is about to leave the sea, the *curves* will furnish the corresponding values of W and T in the foregoing expressions.

Reserve of Buoyancy.—This is a phrase now commonly employed to express the volume and buoyancy of the part of a ship not immersed, but which may be made water-tight. The under-water part of a ship contributes the buoyancy; the out-of-water part the reserve of buoyancy, and the ratio between the two has a most important influence upon the safety of the ship against foundering at sea.

Freeboard.—In its common use freeboard means the height of the upper deck amidships (at the side) above water, and is stated in feet and inches; but this must necessarily be associated in some way with the size of the ship.

"*Lloyd's rule*" allows two inches freeboard per foot depth of hold of eight feet; above that, one-tenth inch for every extra foot depth of hold.

"*Barnaby's rule*" allows one-eighth the beam, with the addition of one thirty-second part of the beam for every beam in the length of the ship above five beams.

THE TONNAGE OF SHIPS.

IT appears that there are in common use the following tonnage measurements:—1. Displacement. 2. Register tonnage. 3. Freight tonnage. 4. Builders' old measurement. 5. Yacht measurement.

It is not to be wondered at that some confusion exists as to the exact meaning of the term "tonnage," seeing it is used in so many senses, sometimes expressing weight, at others capacity, and at others a purely arbitrary function of the principal dimensions.

Respecting "displacement tonnage," it will suffice to say that it expresses the total weight of a ship (in tons) when immersed to her maximum draught, or "load-line."

This is a measurement especially suited for war-ships, which are designed to carry certain maximum weights and to float at certain load-lines that are fixed with reference to desired conditions, such as height of the guns above water, as limitations of draught imposed by the character of the service.

Merchant ships have not to carry certain fixed weights, nor have they usually a fixed maximum load-line. The very various conditions of cargo-stowage to which these ships are liable, entirely separate them from war-ships; the decision as to the draught to which they can be safely laden must vary with the character of the cargo, its mode of stowage, the nature of the voyage, and the season of the year. With some cargoes the ships might be safe at a deeper draught than would make them unsafe with other cargoes on board. Hence, displacement tonnage would not be so fair a measure for merchant ships as it is for ships of war.

Register Tonnage.

Register tonnage is simply the internal capacity of the hold of the ship in cubic feet, with any additional spaces built on deck, divided by one hundred.

The tonnage of a *merchant* ship is usually stated both as "gross" and "nett." "Gross" tonnage expresses (in tons of 100 cubic feet) the total internal capacity of the ship, together with that of any closed-in spaces, such as deck-houses, etc., erected upon the deck for purposes of accommodation or storage. "Nett" tonnage is intended to express in the same units the cubical contents of the space *actually* available for renumerative service, the conveyance of pas-

sengers or stowage of cargo; it is sometimes styled the "register tonnage."

The gross register tonnage of a ship may be found approximately by the following formula:

L = the inside length on upper deck from plank at stem to plank at stern.

B = the inside main breadth from ceiling to ceiling.

D = the inside midship-depth from upper deck to ceiling at limber-strake.

$$\text{Register tonnage} = \frac{L \times B \times D}{100} C$$

Value of C.

Sailing-ships	cotton and sugar ships, old full form,	.8
	ships of the present usual form,	.7
Steam-vessels and clippers	ships of two decks,	.65
	ships of three decks,	.68
Yachts	above sixty tons,	.5
	under sixty tons,	.45

To Calculate the Gross Register Tonnage.

The tonnage deck is the upper deck in all vessels under three decks, in all other vessels the second deck from below. Measurements to be expressed in feet and decimals of a foot. The length for register tonnage is taken from inside of plank at stem to inside of midship stern timber, or plank there as the case may be, and is taken on the tonnage deck; the length so taken (having made reductions for the rake of stem and stern, if any, in the thickness of the deck, and one-third of the round of the beam) is to be divided into the prescribed number of equal parts according to the length, as follows:

Not exceeding 50 feet and under,	6
Exceeding 50 feet and not exceeding 100 feet,	8
" 100 " " 150 "	10
" 150 " " 200 "	12
" 200 " " 250 "	14
" 250 "	16

The area at each point of division is found as follows:

Measure the depth at each point of division from a point distant one-third the round of beam below the line of deck to the inside of planking (average thickness) at side of keelson: if this depth at the midship-division of the length do not exceed sixteen feet, divide each depth into four equal parts, and measure the breadth inside at each of the points of division, and at the upper and lower points of depth. Number these breadths from above in each section; then multiply the second and fourth breadths by four, and the third by two; to the sum of these products add the first and fifth breadths, and multiply the quantity thus obtained by one-third the interval between the breadths—the product is the area of such section.

If the midship-depth exceed sixteen feet, each depth must be divided into six parts, and proceeding as before, multiply the second, fourth and sixth breadth by four, the third and fifth by two, add the products together, and to the sum add the first and seventh breadths, then multiply by one-third the interval as before.

Having found the areas of each section as above, number them from the bow, thus, the one at the bow itself is called one, the next aft is called two, etc.

Then multiply the even-numbered areas, just arranged, by four, the odd-numbered areas (except first and last) by two; to the sum of these products add the first and last areas, if they yield anything, and multiply the result by one-third the interval of length between the areas; this result is the contents of the ship in cubic feet, which, divided by one hundred, is the register tonnage, subject to the following additions.

If there be a poop or other closed-in space on upper deck for cargo, stores, or for accommodation of passengers or crew, its tonnage is to be found by taking the mean length, dividing it into two equal parts, measuring its three inside breadths at the middle of the height, viz.: one at each end and one at the middle of the length; add the end breadths and four times the middle breadth together, and multiply by one-third interval between breadths and by the mean height; then divide by one hundred for the tonnage and add this to the tonnage as found above, under tonnage-deck.

If the ship has a third deck, the tonnage between it and tonnage-deck is found by taking the length at the middle of the height *between decks* from plank at side of stem to the lining on stern-

timbers, and dividing it into the same number of parts as before, measure also at the same height the breadths at each point of division, then, commencing at the stern, number them successively, one, two, three, etc.; multiply the even-numbered breadths by four, the odd-numbered breadths by two (except the first and last); to the sum of these products add the first and last, and multiply by one-third the interval between breadths, and by the mean height; then divide by one hundred, and add the result to the tonnage below tonnage-deck.

In computing the tonnage of open vessels, the upper edge of the upper strake is to form the boundary line of measurement, and the depth shall be taken from an athwart-ship line, extending from the upper edge of said strake at each division of the length.

The register of a vessel expresses the number of decks: the tonnage under the tonnage deck; that of the between decks above the tonnage deck; also that of the poop or other enclosed spaces above the deck, each separately. In every registered United States vessel, the number denoting the total registered tonnage must be deeply carved or otherwise permanently marked upon her main-beam, and shall be so continued; and if at any time it cease to be so continued, such vessel shall be no longer recognized as a registered United States vessel.

The rule adopted in England is essentially the same as that established in this country: the measurements are made in feet and decimals, and the principles of calculation are identical. Vessels are divided as follows: Not exceeding 50 feet in length, into 4 parts; not exceeding 120 feet in length, into 6 parts; not exceeding 180 feet in length, into 8 parts; not exceeding 225 feet in length, into 10 parts; over 225 feet in length, into 12 parts.

Deductions Allowed.—(1) Buildings for the shelter of passengers only; (2) space allotted to crew; (3) space occupied by the propelling-power.

Surveyor's Rule for Approximate Register Tonnage.

L = length in feet. B = breadth in feet. G = girth in feet.
R = approximate gross register tonnage.

$$R = \frac{17}{10{,}000}\left(\frac{G \times B}{2}\right)^2 L \text{ for wood and composite ships.}$$

$$R = \frac{18}{10{,}000}\left(\frac{G \times B}{2}\right)^2 L \text{ for iron vessels.}$$

Factors for Measurement and Dead-weight Cargoes.—1. To ascertain approximately for an average length of voyage the measurement cargo, at forty feet to the ton, which a ship can carry :

RULE.—*Multiply the number of register tons by the factor* 1.875, *and the product will be the approximate measurement cargo.*

2. To ascertain approximately the dead-weight cargo in tons which a ship can carry on an average length of voyage :

RULE.—*Multiply the number of register tons by* 1.5, *and the product will be the approximate dead-weight cargo.*

With regard to the cargoes of coasters and colliers, about ten per cent. may be added to the said results, while about ten per cent. may be deducted in the cases of larger vessels going on long voyages.

In the cases of measurement-cargoes of steam-vessels, the spaces occupied by the machinery, fuel, and passenger-cabins below decks must be deducted from the space or tonnage under the deck before the application of the measurement-factor thereto.

In the case of dead-weight cargoes, the weight of machinery, water in the boilers, and fuel must be deducted from the whole dead-weight, as ascertained above.

The deductions necessary to be made for provisions, stores, etc., are allowed for in the selection of the two factors.

Builder's Tonnage ; or, Old Measurement Tonnage.

To Compute the Builder's Tonnage.

RULE.—Measure the length of the vessel along the rabbet of the keel from the back of the main stern-post to a perpendicular line let fall from the fore part of the main stem under the bowsprit; measure also the extreme breadth to the outside planking, exclusive of doubling-planks. Three-fifths of that breadth is to be subtracted from the length ; the remainder is called the length of keel for tonnage. Multiply the length of keel for tonnage by the breadth, that product by the half-breadth, and divide by 94. The quotient will be the tonnage.

If L=length, B=breadth ; then

$$\text{Tonnage (B. O. M.)} = \frac{(L - \frac{3}{5}B) \times B \times \frac{1}{2}B}{94}$$

Measurement of Yachts for Tonnage.

Royal Thames Yacht Club.

RULE.—Measure the length of the yacht in a straight line at the deck, from the fore part of the stem to the after part of the stern-post, from which deduct the extreme breadth, which is measured from the outside of the outside planking; the remainder is the length for tonnage. Multiply the length for tonnage by the extreme breadth; that product by half the extreme breadth; and divide the result by 94; the quotient will be the tonnage. If any part of the stem or stern-post project beyond the length as taken above, such projection or projections shall, for the purpose of finding the tonnage, be added to the length taken as before mentioned. All fractional parts of a ton shall be considered as a ton. The measurement to be taken either above or below the main-wale.

If L=length, B=breadth, then

$$\text{Tonnage} = \frac{(L-B) \times B \times \frac{1}{2}B.}{94}$$

Corinthian and New Thames Yacht Clubs.

RULE.—Measure the length and breadth as in the foregoing rule, and the depth up to the top of the covering-board; multiply the length, breadth, and depth together, and divide the result by 200; the quotient will be the tonnage.

If L=length, B=breadth, D=depth, then

$$\text{Tonnage} = \frac{L \times B \times D}{200}$$

The New York Yacht Club settle time allowances quite apart from "tonnage." Their tables are based upon the area obtained by multiplying the extreme length of the yacht on or under the water-line, from the fore side of the stem to the aft side of the stern-post, by the extreme breadth wherever found.

Summing up these different rules for yacht measurement, it must be admitted that no plan yet employed is free from objection; the two most trustworthy methods appear to be "displacement tonnage," and "register tonnage."

Danube and Suez Canal Rules.

The so-called "Danube rule" for tonnage, is based upon the English tonnage law of 1854, the allowance for coal and machinery being 50 per cent. above the measured space assigned to machinery in paddle-steamers, and 75 per cent. in screw-steamers.

The tariff of the Suez Canal is also based upon the same law. The dues are charged upon the "net tonnage." The spaces measured for the gross tonnage are: space under the tonnage deck; space between tonnage deck and uppermost deck; all covered or closed-in spaces, such as poop, forecastle, officers' cabins, galleys, cook-houses, deck-houses, wheel-houses, and other inclosed or covered-in spaces employed for working the ship.

The deductions permitted are: berthing accommodation for the crew, not including spaces for stewards and passengers' servants; berthing accommodation for the officers, except the captain; galleys, cook-houses, etc, used exclusively for the crew; covered and closed-in spaces above the uppermost deck, employed for working the ship. In none of these spaces must cargo be carried or passengers berthed, and the total deduction under all these heads must not exceed five per cent. of the gross tonnage. In steamers with *fixed* coal-bunkers, the rule of the English code may be followed, or the owners may choose to have their vessels measured by the Danube rule. Vessels with *shifting* bunkers would be measured by the Danube rule. In no case, except in tugs, must the deduction for the propelling power exceed fifty per cent. of the gross tonnage; so that the minimum tonnage upon which a vessel can pay dues, in passing through the canal, is forty-five per cent. of her gross tonnage.

SAILING.

(*Mackrow.*)

Centre of Lateral Resistance.

The Centre of Lateral Resistance is the centre of application of resistance of the water; and as this varies in position with the speed of the ship, etc., it is not determined, but a point is generally taken at the centre of the immersed longitudinal vertical middle plane of the vessel as sufficiently accurate.

Centre of Effort.

The point in the longitudinal vertical middle-plane of a vessel which is traversed by the resultant of the pressure of the wind on the sails is termed the *centre of effort;* its position varies according to the quantity of sail spread, etc., but its position is determined for purposes connected with designing the sails, all plain sail being taken —that is, the sails that are commonly used, and which can be carried with safety in a fresh breeze.

In calculating the position of the centre of effort the sails are taken braced right fore-and-aft.

To find the Height of the Centre of Effort above the Centre of Lateral Resistance.

RULE.—Multiply the area of each sail by the height of its centre of gravity above the centre of lateral resistance; take the sum of those products (or moments) and divide it by the total area of sail: the quotient will be the required result.

To find the Lateral Position of the Centre of Effort relatively to the Centre of Lateral Resistance.

RULE.—1. Multiply the area of each sail whose centre lies to one side of a vertical axis passing through the centre of lateral resistance by the perpendicular distance of its centre from that axis, and add the products together.

2. Treat the other sails whose centres lie to the other side of the axis of moments in the same way, and add their moments together.

3. The difference between the two sums, divided by the total area of sail, will give the distance of the centre of effort from the given axis.

NOTE.—The centre of effort will lie to that side which has the greatest moment of sail.

Ardency.

Ardency is the tendency a ship has to fly up to the wind, thus showing that the position of her centre of effort is abaft the centre of lateral resistance.

Slackness.

Slackness is the tendency a ship has to fall off from the wind, thus showing that the position of her centre of effort is before the centre of lateral resistance.

Relative Position of Centre of Effort and Centre of Lateral Resistance.

Let D = distance of centre of effort before centre of lateral resistance.
" D_1 = " " " above " "
" d = " " buoyancy of ship below load water-line.
" d_1 = " " lateral resistance abaft the middle of the load-line.
" d_2 = " " lateral resistance before the middle of load-line.
" A = area of load water-line.
" L = length " "

$$D=\frac{L\left(\frac{3}{4}d_1+d_2\right)}{10\left(d_1+d_2\right)}$$ for square-rigged vessels.

$$D=\frac{L}{10\left(d_1+d_2\right)}$$ for fore-and-aft-rigged vessels.

$$D_1=\frac{4A}{5d}$$

The centre of effort of sails to produce the best effect must be higher or lower according as the ship is more or less full at the water-line compared with the fulness of the body at the extremities below the water.

Vessels that are full at the water-line and clean below at the extremities require the higher mast.

Apparent Direction and Velocity of Wind.

Sails are not fixed in position but necessarily move with the ship. *Hence, in* dealing with the propulsive force of a wind, it is neces-

sary to take account also of the motion of the ship; or, as it is usually expressed, it is necessary to determine the apparent direction and velocity of the wind. This can be done easily in any case for which the course and speed of the ship, as well as the true direction and velocity of the wind, are known.

Take the case of a vessel sailing on a wind close-hauled. To simplify matters, let a single square sail be considered, set on the yard X Y in Fig. 11. A B represents the middle line of the ship, the outline of the "plan" being indicated. The line W W_1 represents the *actual* direction of the wind; let M W_1 represent (on a certain scale of feet) its velocity. The line C C shows the course of the ship; and on W_1 D (which is drawn parallel to C C) a length, W_1 D, is set off to represent a motion equal and opposite to that of the ship, the same

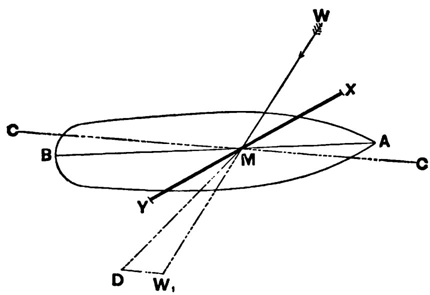


FIG. 11.

scale being used for W_1 D as was employed for the length M W_1. Join M D; then M D represents in magnitude and direction the apparent velocity of the wind. M D is *greater* than the actual velocity M W_1; but its direction makes a *more acute angle* with the sail on X Y than does the actual direction W W_1.

The case of a ship sailing with the wind abaft the beam is illustrated in Fig. 12; the reference letters being the same as those in Fig. 11, *no description is* needed. Here the resultant M D is less

than the actual velocity M W_1; but, as in the previous case, it makes a more acute angle with the sail on X Y.

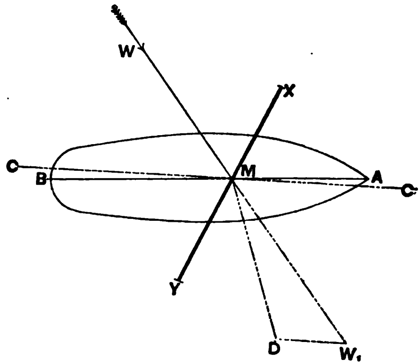


FIG. 12.

Impulse of Wind.

V = velocity of wind in knots per hour.
D = direct impulse in pounds, on one square foot.

$$D = \frac{V^2}{150} = V^2.006667.$$

Speed of Similar Vessels under Sail.

V = velocity of ship. D = displacement of ship.
X = area of midship section. A = area of sails.
c and c_1 constants obtained from similar vessels.

$$V = c\sqrt{\frac{A}{X}} = c_1\sqrt{\frac{A}{D^{\frac{2}{3}}}} \qquad c = \sqrt{\frac{V^2X}{A}} \qquad c_1 = \sqrt{\frac{V^2D^{\frac{2}{3}}}{A}}$$

$$A = \frac{V^2X}{c^2} = \frac{V^2D^{\frac{2}{3}}}{c_1^2}$$

Heeling Moment of Sails.

E = effective impulse of wind on sails.
D = displacement of vessel in pounds.
C = height of centre of effort above centre of lateral resistance.
G = height of metacentre above centre of gravity.
L = length of arm of righting couple at a given angle of heel.
M = heeling moment of sails.
a = angle made by plane of sails with course of ship.
ϕ = angle of heel of vessel.

$$M = C \times E \times \cos. a \times \cos. \phi.$$

The steady angle of heel of a vessel due to M will be that at which
$M = D \times G \times \sin. \phi$ (for small angles of heel).
$M = L \times D$ (for any angle of heel).

In the two last formulæ the reduction in the effective heeling-power of the wind due to the sails being inclined from the upright position has been neglected, but, if necessary, the diminution of the effective pressure of the wind may be taken to vary as the cosine squared of the angle of heel.

NOTE.—In a general sense the moment of sail is understood to be the product of the area of all plain sail into the height of the centre of effort above the centre of lateral resistance, as the pressure of the wind is commonly taken as one pound to the square-foot, and the product of the weight of the ship in pounds into the height of the metacentre above the centre of gravity, divided by the moment of sail, is taken as a measure of her efficiency to resist inclination under canvas.

Area of Sail.

To determine accurately the quantity of sail suitable for any vessel to carry, make the moment of sail equal to the moment of stability at a definite angle of heel. The following rule may, however, be taken as sufficiently approximate:

A = quantity of sail suitable to a given vessel.
D = displacement of vessel in pounds.
M = height of metacentre above centre of gravity.

H = height of centre of effort above centre of lateral resistance.

ϕ = angle of heel in circular measure suitable to a given vessel, taken from the following table.

$$A = \frac{D \times M \times \phi}{H}$$

Angle of Steady Heel for Different Classes of Vessels.

Class of Vessel.	Angle of Heel.	Circular Measure
Frigates and large merchant ships	4°	.070
Corvettes and small merchant vessels ...	5°	.087
Schooners	6°	.105
Yachts	6° to 9°	.105 to .107

Effect of a Gust of Wind on a Ship's Sails.

The effect of a sudden gust upon a ship's sails is, as a rule, to heel her over to an extreme angle of heel of about twice the steady angle at which the same constant pressure of wind would keep her.

USEFUL RULES IN MENSURATION.

I.—To find the circumference of a circle, the diameter being given, and *vice versa*.

1. Multiply the diameter by 3.1416, the result will be the circumference.

2. Divide the circumference by 3.1416, and the result will be the diameter.

II.—To find the area of a circle, the diameter being given, and *vice versa*.

1. Multiply the square of the diameter by .7854. Result—area.

2. Divide the area by .7854, and take the square root of the quotient, the result will be the diameter.

III.—To find the surface of a cylinder, the diameter and length *being* given.

Multiply the diameter by 3.1416 to get the circumference of the section, and again multiply this product by the length.

IV.—To find the volume of a cylinder, the diameter and length being given.

Multiply the square of the diameter by .7854 to get the area of the section, and then multiply this area by the length.

V.—To find the surface of a sphere.

Multiply the diameter of the sphere by its circumference, and its product will be the surface.

VI.—To find the volume of a sphere.

Multiply the cube of the diameter by .5236, and the product will be the volume required.

VII.—To find the volume of a cone.

Proceed as in IV., and divide the result by 3.

VIII.—To find the area of an ellipse.

Multiply the greatest and least diameters together, and that product by .7854, the result will be the area.

IX.—To find the circumference of an ellipse.

Multiply half the sum of the two diameters by 3.1416, and the result will give the circumference sufficiently accurate for practice.

X.—Ar a of a triangle = one-half the base multiplied by the perpendicular.

XI.—Square inches divided by .7854 = circular inches.

Circular inches multiplied by .7854 = square inches.

To Find the Weight of a Known Substance of Given Dimensions.

Having found the volume, if the result be in cubic feet, multiply by the weight of a cubic foot; but if the volume be in cubic inches, multiply by the weight of a cubic inch, and divide the product so obtained by 1728.

Area of a square = square of one side.

Side of a square = square root of area.

Area of a parallelogram = length × perpendicular breadth.

Square inches × .007 = square feet.

Cubic inches × .00058 = cubic feet.

Cubic *inches* × *.003617* = imperial gallon (nearly).

Cubic feet × 6.252 = imperial gallon.
Avoirdupois pounds × .00893 = hundred-weights.
Avoirdupois pounds × .00045 = tons.

To Calculate the Floating Power of Spars, Casks, etc.

The weight they will sustain is the difference between their own weight and that of the water which they displace.

To ascertain the weight, multiply the square of the mean diameter in inches by .7854 to find the area; multiply the area by the length to find the cubic contents, and the product by the weight of a cube foot of the material.

Example.—Top-mast.—Length = 64 feet; main diameter = 21 in.; 64 feet = 768 inches; and $\frac{21^2 \times .7854 \times 768}{1728} = 154$ cubic inches; 154 × 64.18 (the weight in pounds of one cubic foot of salt water) = 9,883.7 pounds; 154 × 363 (the weight in pounds of one cubic foot of Norway spars); floating power of spar, $\frac{5{,}590.2 \text{ pounds}}{4{,}293.5 \text{ pounds}} = 38$ hundred-weight.

To find the contents of square or four-sided timber, multiply the mean breadth by the mean thickness, and the product by the length.

To find the solid contents of round timber, multiply the square of one-fifth of the mean girth by twice the length,

In making use of tanks, casks, etc., for floating purposes, the internal capacity is immediately obtained by multiplying the gallons it holds by 10, and subtracting the weight of the tank or cask. This gives the floating power in pounds.

In constructing a raft, it should be borne in mind that all the weight of human beings is to be placed *on* it, and that a great quantity of provisions and water may be safely carried *under* it.

For instance, a cask of beef slung beneath would be 116 pounds; above, 300 pounds.

In calculating the floating powers of casks, the weight of the casks themselves need not be taken into consideration, as when they are submerged it is inappreciable.

THE UNITED STATES LIFE-SAVING SERVICE.

As now organized, the Life-Saving Service embraces twelve districts, comprising one hundred and ninety-five stations, which are divided into three classes, known as *Life-saving Stations*, *Life-boat Stations*, and *Houses of Refuge*.

Each district is in charge of a superintendent, who is required to be an inhabitant of the region, and familiar with the use of surf-boats and life-saving apparatus.

The superintendent nominates the keepers of his district, who must be experienced surf-men.

Each district is in charge of the keeper, who is by law an inspector of customs, and is authorized to take charge of all property cast on shore, and to prevent smuggling. He is responsible for the condition of the station, commands the crew, and conducts all operations.

All Life-saving Stations are fully supplied with wreck-guns, boats, beach apparatus, and all things necessary for ministering to the immediate wants and comforts of those saved. They also furnish quarters for the keepers and crews.

The majority of the stations are provided with the international code of signals, and vessels can have themselves reported, obtain the latitude and longitude of the station, information as to weather probabilities, or, if disabled, request the services of a steam-tug.

The crews patrol the beach four miles on each side of their stations four times between sunset and sunrise, and in foggy weather throughout the day.

Each man carries Coston signals, and upon discovering a vessel standing into danger, one of them is ignited to warn her; or, in case of the vessel being on shore, to inform the crew that assistance is at hand.

Life-boat stations are also fully furnished with life-saving apparatus, boats, wreck-guns, restoratives, etc.

The keeper is required to live near at hand, keep a bright lookout for distressed vessels, and to rally the men when needed.

Volunteer crews of eight men are enrolled, and they are required to be vigilant to observe the signal for their assembly in stormy weather.

Houses of refuge located on the Florida coast are supplied with

boats, provisions, and restoratives, but not manned with crews. A keeper resides in each during the year, who, after every storm, is required to make extended trips along the coast to find and succor any persons that may have been cast on shore.

Instructions for the Guidance of Masters and Seamen when Using the Apparatus for Saving Life in Cases of Shipwreck.

IN case a vessel is not discovered at once after striking, rockets or flare-up lights should be burned; or, in foggy weather, guns fired to attract attention.

When driven on shore near a station, the crew should remain by their vessel until assistance arrrives, and should not attempt to land through the surf in their own boats until all hope of assistance from the shore is gone.

On the discovery of a vessel in distress, the boat is launched and proceeds to the wreck, if practicable. Upon its reaching the vessel, the directions of the keeper, who steers the boat, should be followed. Women, children, and invalids should be passed into the boat first, then the remaining passengers and crew. The *Captain* should remain on board until the last, to preserve order.

No baggage or other goods are to be taken into the boat until all are landed.

When the life-boats cannot be used, recourse is had to the wreck-gun and beach apparatus, and the people landed by means of the life-car or the breeches-buoy.

A shot, with a small line attached, is fired across the vessel. This line should be at once hauled in until a tail-block, with a whip rove through it, is received. Attached to the block will be found a board, with directions in English and French, as follows: "*Make the tail of the block fast to the lower-mast well up.*" If the masts are gone, secure it as high up as possible.

Cast off the shot-line; see that the rope runs freely through the block; and signal to shore by waving a hat, flag, or handkerchief; or, if at night, let a rocket, a blue-light, or a gun be fired; or let a light be displayed over the ship's side and be again concealed.

As soon as the signal is seen, a light hawser will be bent to the whip, and hauled off to the ship by the shore people. The crew can also assist, by hauling on the whip on board the vessel.

When the end of the hawser is at hand, a board will be discovered having the following directions in English and French: "*Make this hawser fast about two feet above the tail-block; see all clear, and show signal to the shore.*"

Care should be taken that there are no turns of the whip round the hawser before the latter is made fast.

When the hawser is fast and the whip clear for running, the hawser will be hauled taut on shore, and by means of the whip a life-car, suspended from rings running on the hawser, or the breeches-buoy, hung from a traveller-block, will be sent off.

If the breeches-buoy be sent, a man should at once get into it, placing his legs through the breeches. If the car, the hatch must be opened; as many persons placed inside as it will hold (generally six); and the hatch secured outside by the bar and hook. Signals should then be made, and the car will be hauled ashore. This will be repeated until all are landed. On the last trip of the car, the hatch must be secured by the inside bar. Children may be brought on shore in the buoy, by being held in the arms of older persons, or securely lashed to the buoy.

If the strength of the current, or danger of the wreck breaking up immediately, make it advisable not to send off the hawser, the breeches-buoy or life-car will be hauled off by the whip or line, and the people landed through the surf.

If a vessel is stranded at night, and the red light which announces its discovery by the patrol-man be seen, a bright lookout should be kept for the boat, which may not arrive for from one to four hours, according to circumstances.

Lights on the beach will show the arrival of the crew opposite the vessel, and the sound of guns may be taken as evidence that a line has been fired across the vessel. A strict search should, therefore, be made aloft for the line.

To sum up:

Remain by the wreck, unless the vessel is breaking up.

If not at once discovered, burn rockets or flare-up lights, and in foggy weather, fire guns.

See the whip clear before making the hawser fast.

Send women and children on shore first.

Keep cool, and attend to the foregoing rules.

LIFE-SAVING DISTRICTS AND STATIONS OF THE UNITED STATES.

First District.

Coasts of Maine and New Hampshire.

No.	Name.	State.	Locality.	Latitude, north. °	′	″	Longitude, west. °	′	″
1	West Quoddy Head	Me	Carrying Point Cove	44	48	25	66	58	25
2	Cross Island	Me	Off Machiasport	44	37	28	67	16	20
3	Crumple Island	Me	Off Jonesborough	44	28	30	67	37	00
4	Little Cranberry Island.	Me	Off Mount Desert	Not determined.					
5	Whitehead Island	Me	Near Whitehead light	43	58	41	69	07	37
6	Biddeford Pool	Me	Fletcher's Neck	43	26	32	70	20	08
7	Locke's Point	N. H	Rye Beach	42	59	31	70	45	00
	Second District. *Coast of Massachusetts.*								
1	Plum Island	Mass	Near Newburyport, 3 miles distant	42	47	05	70	48	41
2	Davis Neck	Mass	Near Annisquam light	42	40	03	70	40	03
3	Scituate	Mass	South end of fourth cliff	Not determined.					
4	Gurnett's	Mass	8 miles northeast of Plymouth	42	00	10	70	35	50
5	Manomet Point	Mass	7 miles southeast of Plymouth	41	55	29	70	32	18
6	Race Point	Mass	⅝ mile northeast of Race Point light, Cape Cod	42	04	12	70	13	56
7	Peaked Hill Bar	Mass	2½ miles northeast of Provincetown, Cape Cod	42	04	34	70	08	54
8	Highlands	Mass	⅞ mile northwest of light, Cape Cod	42	02	47	70	04	05
9	Parmet River	Mass	3½ miles south of Highland light	41	59	59	70	00	53
10	Cahoon's Hollow	Mass	2½ miles east of the town of Wellfleet	41	56	38	69	58	40
11	Nausett	Mass	1¾ mile south of lights	41	50	29	69	56	20
12	Orleans	Mass	Abreast of Ponchet Island	41	45	31	69	55	31

13	Chatham	Mass.	2 miles north of Chatham light	41	42	12	69	56	34
14	Monomoy	Mass.	2 miles north of Monomoy light	41	36	00	69	58	41
15	Surfside	Mass.	2½ miles south of the town of Nantucket.	41	14	33	70	08	36

Third District.

Coasts of Rhode Island and Long Island.

1	Narragansett Pier	R. I.	Northern part of the town	41	25	59	71	27	04
2	Point Judith	R. I.	Near light-house	41	21	38	71	28	54
3	Watch Hill	R. I.	Do	41	18	12	71	51	32
4	New Shoreham	R. I.	Block Island, east side, near landing	41	10	30	71	33	07
5	Block Island	R. I.	Block Island, west side, near Dickens' Point	41	09	41	71	36	13
6	Montauk Point	N. Y.	At the light	41	04	07	71	51	00
7	Ditch Plain	N. Y.	3 miles southwest of Montauk light	41	02	19	71	54	38
8	Hither Plain	N. Y.	½ mile southwest of Fort Pond	41	01	33	71	57	26
9	Napeague	N. Y.	Abreast Napeague Harbor	40	59	38	72	02	24
10	Amagansett	N. Y.	Abreast of the town	40	58	05	72	07	24
11	Georgica	N. Y.	1 mile south of East Hampton	40	56	35	72	11	19
12	Bridgehampton	N. Y.	2 miles south of town	40	54	06	72	17	41
13	Southampton	N. Y.	¾ mile south of town	40	52	13	72	23	07
14	Shinnecock	N. Y.	3 miles from the head of Shinnecock Bay	40	50	40	72	27	30
15	Tyana	N. Y.	4 miles east of Quogue	40	49	36	72	31	16
16	Quogue	N. Y.	½ mile south of the village	40	48	23	72	35	41
17	West Hampton	N. Y.	1½ mile southwest of Patunk village	40	47	52	72	39	01
18	Moriches	N. Y.	2½ miles southwest of Speonk village	40	46	25	72	42	49
19	Forge River	N. Y.	3½ miles south of Moriches	40	44	56	72	48	12
20	Smith's Point	N. Y.	Abreast of the point	40	43	51	72	52	20
21	Bellport	N. Y.	4 miles south of the village	40	42	42	72	55	46
22	Blue Point	N. Y.	4½ miles south of Patchogue	40	40	40	73	01	15
23	Lone Hill	N. Y.	4½ miles south of Sayville	40	39	46	73	04	27
24	Point of Woods	N. Y.	5 miles south of Islip	40	38	55	73	08	11
25	Fire Island	N. Y.	East side Fire Island Inlet	40	37	34	73	13	36
26	Oak Island, east end	N. Y.		40	38	15	73	17	39
27	Do. west end	N. Y.		40	37	16	73	22	24
28	Jones's Beach, east end	N. Y.		40	36	27	73	25	20
29	Do. west end	N. Y.	6 miles south of South Oyster Bay	40	36	10	73	28	43

35

Life-Saving Districts and Stations on Coasts of the United States.—*Continued.*

Third District—*Continued.*

No.	Name.	State.	Locality.	Approximate position. Latitude, north. °	′	″	Longitude, west. °	′	″
30	Short Beach	N. Y.	⅛ mile east of Jones's Inlet	Not determined.					
31	Discontinued.								
32	Long Beach, east end	N. Y.	2 miles west of Jones's Inlet	40	35	18	73	35	47
33	Do. west end	N. Y.	Near Lucy's Inlet	40	35	03	73	39	09
34	Hog Island, west end	N. Y.	Near Hog Island Inlet	40	35	22	73	43	50
35	Rockaway Beach	N. Y.	Near the village of Rockaway	40	35	25	73	46	55
36	Do.	N. Y.	West end	40	34	15	73	51	08
37	Coney Island	N. Y.	Manhattan Beach	40	34	21	63	56	05
38	Eaton's Neck	N. Y.	East side entrance to Huntington Bay, Long Island Sound	40	57	12	73	23	45

Fourth District.

Coast of New Jersey.

No.	Name.	State.	Locality.	Latitude °	′	″	Longitude °	′	″
1	Sandy Hook	N. J.	383 yards east of main light	40	27	42	73	59	34
2	Spermaceti Cove	N. J.	East of the upper end of cove	40	25	39	73	58	50
3	Seabright	N. J.	About a mile south of Navesink lights	40	22	46	73	58	11
4	Monmouth Beach	N. J.	3⅛ miles south of Navesink lights	40	20	30	73	58	07
5	Long Branch	N. J.	Near Green's Pond	40	16	36	73	58	43
6	Deal	N. J.	Near the town, 328 yards north of Great Pond	40	14	00	73	59	29
7	Shark River	N. J.	Near the mouth of Shark River	40	11	25	74	00	19
8	Wreck Pond	N. J.	2⅛ miles below Shark River	40	09	20	74	00	56
9	Squan Beach	N. J.	1 mile southeast of Squan Village	40	06	52	74	01	43
10	Point Pleasant	N. J.	At the head of Barnegat Bay	40	03	58	74	02	20
11	Swan Point	N. J.	2⅜ miles below the head of Barnegat Bay	40	01	37	74	03	15

12	Green Island	N. J.	5 miles below the head of Barnegat Bay.	39	59	06	74	03	33
13	Tom's River	N. J.	On the beach abreast of its mouth	39	56	15	74	04	30
14	Island Beach	N. J.		39	53	42	74	04	57
15	Forked River	N. J.		39	51	06	74	05	16
16	South end Island Beach.	N. J.	North side of Barnegat Inlet	39	48	08	74	05	40
17	Barnegat	N. J.	South side of Barnegat Inlet	39	45	34	74	06	13
18	Loveladies Island	N. J.	On the beach abreast of the island	39	43	47	74	07	01
19	Harvey Cedars	N. J.		39	40	23	74	08	13
20	Ship Bottom	N. J.		39	38	13	74	10	43
21	Long Beach	N. J.		39	35	03	74	13	03
22	Bond's	N. J.		39	31	59	74	15	16
23	Little Egg	N. J.	Near the light north of inlet	39	30	05	74	17	28
24	Little Beach	N. J.	South side of Little Egg Inlet	39	27	23	74	19	28
25	Brigantine	N. J.	5½ miles above Absecom light	39	25	23	74	20	02
26	Discontinued.								
27	Atlantic City	N. J.	Near Absecom light	39	21	57	74	24	31
28	Absecom	N. J.	3 miles below the light	39	20	45	74	27	27
29	Great Egg	N. J.	6 miles below the light	39	19	02	74	30	51
30	Beazleys	N. J.	South side of the inlet	39	17	10	74	34	30
31	Peck's Beach	N. J.	3½ miles above Corson's Inlet	39	14	47	74	36	29
32	Corson's Inlet	N. J.	Near the inlet, north side	39	12	59	74	38	06
33	Ludlam's Beach	N. J.	3¼ miles above Townsend's Inlet	39	09	42	74	40	41
34	Townsend's Inlet	N. J.	Near the inlet, north side	39	07	30	74	42	21
35	Stone Harbor	N. J.	3½ miles above Hereford Inlet	39	03	35	74	44	50
36	Hereford Inlet	N. J.	Near Hereford light	39	00	14	74	46	55
37	Turtle Gut	N. J.	6 miles above Cape Island City	38	58	39	74	50	24
38	Two-Mile Beach	N. J.	4 miles above Cape Island City	38	57	08	74	51	00
39	Cape May	N. J.	2 miles above Cape Island City	38	56	01	74	54	00
40	Do.	N. J.	Near the light	38	55	50	74	57	36
41	Bay Shore	N. J.	2½ miles west of Cape Island City	38	56	37	74	58	03

Fifth District.

Coast between Cape Henlopen and Cape Charles.

1	Cape Henlopen	Del.		38	46	38	75	04	43
2	Rehoboth Beach	Del.		Not determined.					
3	Indian River Inlet	Del.		38	36	40	75	04	30

Life-Saving Districts and Stations on Coasts of the United States.—*Continued.*

Fifth District—*Continued.*

No.	Name.	State.	Locality.	Approximate position. Latitude, north. °	′	″	Longitude, west. °	′	″
4	Ocean City	Md	Just north of town	Not determined.					
5	Green Run Inlet	Md		38	03	15	75	13	15
6	Pope's Island	Md		Not determined.					
7	Assateague Beach	Va.	Abreast of Assateague light	37	54	10	75	19	35
8	Cedar Inlet	Va.	South end of Cedar Island	37	35	10	75	36	20
9	Hog Island	Va.	South end of Hog Island	37	26	45	75	41	00
10	Cobb's Island	Va.	South end of Cobb's Island	37	17	20	75	46	15
11	Smith's Island	Va.	South end of Smith's Island	37	06	20	75	55	00
	Sixth District.								
	Coast between Cape Henry and Cape Fear.								
1	Cape Henry	Va.		36	55	30	76	00	30
2	Seatack	Va.		Not determined.					
3	Dam Neck Mills	Va.		Do.					
4	Little Island	Va.		Do.					
5	False Cape	Va.		26	38	15	75	53	00
6	Deal's Island	N. C.		Not determined.					
7	Old Currituck Inlet	N. C.		Do.					
8	Jones's Hill	N. C.	Currituck Beach	36	22	00	75	49	00
9	Poyner's Hill	N. C.		Not determined.					
10	Caffey's Inlet	N. C.		Do.					
11	Paul Gamiel's Hill	N. C.		Do.					
12	Kitty Hawk	N. C.		Do.					
13	Kill Devil Hills	N. C.		Do.					
14	Nag's Head	N. C.	8 miles north of Oregon Inlet	35	55	30	75	36	15

15	Tommy's Hummock....	N. C...	....	Not determined.					
16	Bodie's Island	N. C...	⅛ mile south of Oregon Inlet..........	35	47	30	75	32	00
17	Pea Island..............	N. C...	....	Not determined.					
18	Chicamicomico	N. C...	5 miles south of New Inlet	35	35	30	75	27	30
19	Cedar Hummock.......	N. C...	....	Not determined.					
20	Little Kinnakeet.......	N. C...	....	35	24	30	75	28	30
21	Big Kinnakeet..........	N. C...	6 miles north of Cape Hatteras lighthouse..........	Not determined.					
22	Creed's Hill...	N. C...	4⅛ miles west of Cape Hatteras lighthouse..........	Do.					
23	Hatteras	N. C...	3 miles east of Hatteras Inlet..........	Do.					
24	Cape Lookout..........	N. C...	Station not yet built.						
25	Cape Fear	N. C...	Do.						

Seventh District.

Eastern Coast of Florida.

1	Thirteen miles north of Indian River Inlet....	Fla....	....	Not determined.					
2	Gilbert's Bar...........	Fla....	St. Lucie Rocks..........................	Do.					
3	Orange Grove..........	Fla....	....	Do.					
4	Fort Lauderdale........	Fla....	....	Do.					
5	Biscayne Bay	Fla....	....	Do.					

Eighth District.

Gulf Coast of United States.

1	Sabine Pass............	Tex....	....	Not determined.					
2	Galveston, east end of island................	Tex ...	Station not yet built.						
3	Galveston, west end of island	Tex....	....	Not determined.					
4	Pass Cavallo...	Tex....	....	Do.					
5	Aranzas Pass	Tex....	....	Do.					
6	Brazos Santiago........	Tex....	....	Do.					

Life-Saving Districts and Stations on Coasts of the United States.—*Continued.*

Ninth District.

Lakes Erie and Ontario.

No.	Name.	State.	Locality.
1	Big Sandy Creek	N. Y.	East side of mouth of Big Sandy Creek, Lake Ontario.
2	Salmon Creek	N. Y.	East side of mouth of Salmon Creek, Lake Ontario.
3	Oswego	N. Y.	Entrance of Oswego Harbor, Lake Ontario.
4	Charlotte	N. Y.	Entrance of Charlotte Harbor, Lake Ontario.
5	Buffalo	N. Y.	In the Harbor, Buffalo, Lake Erie.
6	Presque Isle	Pa.	Entrance of Erie Harbor, Lake Erie.
7	Fairport	Ohio.	Entrance of Fairport Harbor, Lake Erie.
8	Cleveland	Ohio.	Entrance of Cleveland Harbor, Lake Erie.
9	Marblehead Point	Ohio.	Marblehead Island, near Quarry Docks, Lake Erie.

Tenth District.

Lakes Huron and Superior.

1	Sand Beach Harbor	Mich	Lake Huron. Station not yet built.
2	Point aux Barques	Mich	Near light-house, Lake Huron.
3	Port Austin	Mich	Lake Huron. Station not yet built.
4	Ottawa Point (Tawas)	Mich	Near light-house, Lake Huron.
5	Sturgeon Point	Mich	Do.
6	Thunder Bay Island	Mich	Do.
7	Middle Island	Mich	Lake Huron. Station not yet built.
8	Forty Mile Point	Mich	Hammond's Bay, Lake Huron.
9	Vermilion Point	Mich	Lake Superior.
10	Seven miles west of Vermilion Point	Mich	Do.
11	Two Heart River	Mich	Near mouth of Two Heart River, Lake Superior.
12	Sucker River	Mich	Near mouth of Sucker River, Lake Superior.
13	Ship Canal	Mich	Near mouth of Portage Lake and Lake Superior Ship Canal, Lake Superior. Station not yet built.

Eleventh District.

Lake Michigan.

1	Beaver Island	Mich	Near light-house.
2	North Manitou Island	Mich	Near Pickard's wharf.
3	Sleeping Bear Point	Mich	Station not yet built.
4	Point au Bec Scies	Mich	Near light-house.
5	Manistee	Mich	In the harbor.
6	Grand Point au Sable	Mich	Near light-house.
7	Ludington	Mich	In the harbor.
8	Muskegon	Mich	In the harbor at Port Sherman.
9	Grand Haven	Mich	Entrance of harbor.
10	Saint Joseph	Mich	In the harbor.
11	Chicago	Ill	Do.
12	Grasse Point	Ill	Evanston, Ill., on Northwestern University Grounds.
13	Kenosha	Wis	In the harbor on Washington Island.
14	Racine	Wis	In the harbor.
15	Milwaukee	Wis	Near entrance of harbor.
16	Sheboygan	Wis	Entrance of harbor.
17	Two Rivers	Wis	Do.
18	Bayley's Harbor	Wis	Station not yet built.

Twelfth District.

Pacific Coast.

1	Neah Bay	Wash. Ter.	On Indian reservation.
2	Shoalwater Bay	Wash. Ter.	Near light-house boat-landing.
3	Cape Disappointment	Wash. Ter.	Baker's Bay.
4	Cape Arago	Oregon	Coos Bay, near light-house.
5	Humboldt Bay	Cal	Near light-house.
6	Bolinas Bay	Cal	Station not yet built.
7	Golden Gate Park	Cal	On beach in Golden Gate Park, San Francisco.
8	Point Concepcion	Cal	Station not yet built.

HINTS TO BATHERS.

AVOID bathing within TWO hours after a meal.

Avoid bathing when exhausted by fatigue or any other cause. Avoid bathing when the body is cooling after perspiration; but bathe when the body is warm, provided no time is lost in getting into the water. Avoid chilling the body by sitting or standing NAKED on the banks or in boats after having been in the water.

Avoid remaining too long in the water—leave the water immediately there is the slightest feeling of chilliness.

Avoid bathing altogether in the open air, if after having been a short time in the water there is a sense of chilliness, with numbness of the hands and feet.

The vigorous and strong may bathe early in the morning on an empty stomach; the young and those who are weak had better bathe three hours after a meal. The best time for such is from two to three hours after breakfast.

ALL that is necessary to keep a person from drowning in deep water is to keep the water out of the lungs. Suppose yourself a bottle—your nose is the mouth of the bottle, and must be kept out of the water; if it goes under, do not breathe at all till it comes out; keep legs, arms, all under but your nose; do that, and you cannot sink in any depth of water. All you need do to secure this is to clasp your hands behind your back, point your nose upward toward the heavens, and keep perfectly still. Your nose will never go under water unless you raise your chin, hand, knee, or foot above it.

INSTRUCTIONS FOR SAVING DROWNING PERSONS BY SWIMMING TO THEIR RELIEF.

FIRST.—When you approach a drowning person in the water, assure him with a loud and firm voice that he is safe.

SECOND.—Before jumping in, divest yourself, as far and as quickly as possible, of all clothes—tear them off if necessary; but, if there is no time, loose, at all events, the foot of your drawers if they are tied, as if you do not do so they fill with water and drag you.

THIRD.—On swimming to any person in the sea, if they are struggling, do not seize them then, but keep off for a few seconds till they get quiet, for it is sheer madness to take hold of them when they are struggling in the water; if you do, you run a great risk.

FOURTH.—Then get close to them and take fast hold of the hair of the head, turn them as quickly as possible on their back, give them a sudden pull, and this will cause them to float; then throw yourself on your back also and swim for the shore, both hands having hold of their hair, you on your back and they also on theirs, and of course their back to your stomach. In this way you will get sooner and safer ashore than by any other means, and you can easily thus swim with two or three persons; the writer has even, as an experiment, done it with four, and gone with them forty or fifty yards in the sea. One great advantage of this method is that it enables you to keep your head up, and also to hold the person's head up you are trying to save. It is of primary importance that you take fast hold of the hair, and throw both the person and yourself on your backs. After many experiments it is usually found preferable to all other methods. You can in this manner float nearly as long as you please, or until a boat or other help can be obtained.

FIFTH.—It is believed there is no such thing as a *death-grasp*, at least it is very unusual to witness it. As soon as drowning persons begin to get feeble and to lose recollection, they gradually slacken their hold until they quit it altogether. No apprehension need therefore be felt on that head when attempting to rescue a drowning person.

SIXTH.—After a person has sunk to the bottom, if the water be smooth, the exact position where the body lies may be known by the air-bubbles which will occasionally rise to the surface, allowance being of course made for the motion of the water if in a tideway or stream, which will carry the bubbles out of the perpendicular course in rising to the surface. A body may be often regained from the bottom before too late for recovery, by diving for it in the direction indicated by these bubbles.

SEVENTH.—On rescuing a person by diving to the bottom, the hair of the head should be seized by one hand only, and the other used in conjunction with the feet in raising yourself and drowning person to the surface.

EIGHTH.—If in the sea, it may sometimes be a great error to try and get to land. If there be a strong "outsetting" tide and you are swimming, either by yourself or having hold of a person who cannot swim, *then get on* your back and float till help comes.

NINTH.—These instructions apply alike to all circumstances, whether the roughest sea or smooth water.

TREATMENT OF THE APPARENTLY DROWNED.

The Following Directions for Restoring the Apparently Drowned are from the Latest Instructions issued by our Life-Saving Service; they are those of DR. HOWARD.

WHERE you can do so, send immediately for a regular medical practitioner.

RULE I.—*Arouse the Patient.*—Unless in danger of freezing, do not move the patient, but instantly expose the face to a current of fresh air, wipe dry the mouth and nostrils, rip the clothing, so as to expose the chest and waist, and give two or three quick smarting slaps on the stomach and chest with the open hand. If the patient does not revive, proceed thus:

RULE II.—*To Draw off Water, etc., from the Stomach and Chest.*—If the jaws are clinched, separate them, and keep the mouth open by placing between the teeth a cork, or small bit of wood; turn the patient on the face, a large bundle of tightly rolled clothing being placed beneath the stomach, and press heavily over it for half a minute, or so long as fluids flow freely from the mouth.

RULE III.—*To Produce Breathing.*—Clear the mouth and throat of mucus by introducing into the throat the corner of a handkerchief wrapped closely around the forefinger; turn the patient on the back, the roll of clothing being so placed as to raise the pit of the stomach above the level of any other portion of the body. If there be another person present, let him, with a piece of dry cloth, hold the tip of the tongue out of one corner of the mouth (this prevents the tongue from pulling back and obstructing the windpipe), and with the other hand grasp both wrists, and keep the arms forcibly stretched back above the head, thereby increasing the prominence of the ribs, which tends to enlarge the chest. The two last-named positions are not, however, essential to success. Kneel beside or astride the patient's hips, and with the balls of the thumbs resting on either side of the pit of the stomach, let the fingers fall into the grooves between the short ribs, so as to afford the best grasp of

the waist. Now, using your knees as a pivot, throw all your weight forward on your hands, and at the same time squeeze the waist between them, as if you wished to force everything in the chest upward out of the mouth; deepen the pressure while you can count slowly one, two, three; then suddenly let go with a final push, which springs you back on your first kneeling position. Remain erect on your knees while you can count one, two, three; then repeat the same motions as before, at a rate gradually increased from four or five to fifteen times in a minute, and continue thus this bellows movement, with the same regularity that is observable in the natural motions of breathing which you are imitating. If natural breathing be not restored after a trial of the bellows movement for three or four minutes, then, without interrupting the artificial respiration, turn the patient a second time on the stomach, as directed in Rule II., rolling the body in the opposite direction from that in which it was first turned, for the purpose of freeing the air passages from any remaining water. Continue the artificial respiration from one to four hours, or until the patient breathes; and for a while after the appearance of returning life, carefully aid the first short gasps until deepened into full breaths. Continue the drying and rubbing, which should have been unceasingly practised from the beginning, taking care not to interfere with the means employed to produce breathing. Thus, the limbs of the patient should be rubbed, always in an upward direction toward the body, with firm grasping pressure and energy, using the bare hands, dry flannels or handkerchiefs, and continuing the friction under the blankets or over the dry clothing. The warmth of the body can also be promoted by the application of hot flannels to the stomach and armpits, bottles or bladders of hot water, heated bricks, stones, etc., to the limbs and soles of the feet.

RULE IV.—*After-Treatment.*—*Externally:* As soon as breathing is established, let the patient be stripped of all wet clothing, wrapped in blankets only, put to bed comfortably warm, but with a free circulation of fresh air, and left to perfect rest. *Internally:* Give a little brandy and hot water, or other stimulant at hand, every ten or fifteen minutes during the first hour, and as often thereafter as may seem expedient. *Later manifestations:* After reaction is fully established there is great danger of congestion of the lungs, and if *perfect* rest is not maintained for at least forty-

eight hours, it sometimes occurs that the patient is seized with great difficulty of breathing, and death is liable to follow unless immediate relief is afforded. In such cases apply a large mustard plaster over the breast. If the patient gasps for breath before the mustard plaster takes effect, assist the breathing by carefully repeating the artificial respiration.

ACCIDENTS, INJURIES, AND POISONS.

Rules to be Followed where Surgical Assistance Cannot be at Once Obtained.

The dangers to be feared are: *Shock*, *loss of blood*, and *suffering* in moving the patient.

In *shock* the injured person lies pale, faint, and sometimes insensible. A person with such symptoms should, if possible, be placed flat on the back, with the head and shoulders *slightly* raised. The cravat and collar should be loosened or removed. If the injury is slight, reaction will soon come on after giving a little spirits and water, or aromatic spirits of ammonia and water, every couple of minutes. External warmth should be applied to the limbs and the pit of stomach, and the body well wrapped in blankets to assist reaction. Bottles of hot water, or hot bricks, may also be wrapped in cloths, and placed along the sides and between the legs.

Food, in the shape of strong soup, should be given now and then.

If the weather is hot, a palm-leaf fan will assist greatly; also a little eau de cologne on a handkerchief, applied to the nostrils.

Loss of Blood.—To check the flow of blood from a wound, the principle to be acted upon is to check the flow of blood to the part. Should the bleeding be from an artery, in which case it comes forth in spurts and is of a bright red color, *pressure* must be made on the main artery of the limb, *above* the wound, on the side of the wound nearest the heart.

If the blood be from a wounded vein, it flows in a stream and is of a dark color; in this case pressure must be made *below* the wound for a short time, after which a small pad of lint and a bandage over the wound will suffice.

To check the current of blood in the main artery of the arms or legs, feel for the artery on the inner side of the limbs, where it will

be recognized by its pulsations; lay a firm compress across the course of the artery, pass a handkerchief around the limb and compress; pass a stick under the handkerchief, on the outer side of the limb, and twist it until sufficient tightness is produced to arrest the bleeding; then secure the stick to prevent its untwisting.

The arteries will be found coursing toward the inner side of both limbs. In applying the tourniquet or handkerchief, the pad should be on the inner side, the screw or knot on the outer side of the limb. A compress or pad may be made of a piece of wood, a cork, or round stone wrapped in cloth. Care should be taken to examine the limb from time to time, and to lessen the constriction if it becomes very cold or purple; tighten the tourniquet if the bleeding begins afresh.

Elevation of the wounded part above the rest of the body will contribute much to check the bleeding.

The application of cold is good when the bleeding is from several points scattered over a large surface; it is conveniently applied by letting cold water drip from a sponge upon the bleeding points, or by the application of ice in a rubber-bag.

When these immediate measures have been used, there is time to use what physicians call "hæmostatics," to stop the blood. Alum or gallic acid may be dusted on the part in powder, or poured over it in solution. Tincture of iron and nitrate of silver are also used.

Fractures.—If any of the limbs be fractured, they should be temporarily splintered with two or four pieces of light wood tied at each end with handkerchiefs passed twice round, like an old-fashioned necktie. If a broken limb be not splintered, the ends may be forced through the skin if the patient be carried.

To transport a wounded person, let the patient be laid on a door or some firm support, properly covered Have sufficient force to lift steadily, and the bearers should *not* keep step.

Dislocations.

Whenever a bone is dislocated, there is a deformity at joint and loss of motion.

The sufferer usually becomes faint. While this condition exists, an attempt should be made to reduce the bone into position. It is

surprising how easily this may be done, if it be tried at once, by extension and counter-extension by jack-towels or sheets.

If, for example, the dislocation takes place at the shoulder-joint, a clove-hitch by towel should be applied above the elbow-joint, and steady traction made in the direction of the axis of the bone by a strong man, while two others make counter-extension by another towel or sheet in the arm-pit, crossed toward the sound shoulder. This may be held by two men, or made fast to a ring-bolt; or the heel may be placed in the arm-pit, while a towel is clove-hitched above the elbow-joint. The limb should be steadily pulled downward, while the heel assists to force the head of the dislocated bone outward and upward into its natural position. A loud snap is always heard when the bone returns into its socket.

Dislocation at Hip.—Clove-hitch above knee; second sheet on inside of thigh for counter-extension; and make fast to bolt on deck or ship's side.

Bruises.—Use hot-fomentations at first. After inflammation has subsided, use stimulating applications, as vinegar and water, alcohol, etc.

Sprains.—Elevate the limb; keep the joint perfectly quiet; apply lukewarm lotions or fomentations. When inflammation has ceased apply stimulating liniments, as soap or camphor liniments, and bandages; shower the part with cold water, alternating with warm water, or the hot and cold douches.

Burns or Scalds.

Do not cut the bladder. The readiest application may be flour from the dredging-box, laid on thick as possible. Lime-water and oil in equal parts is excellent, covered with cotton-wadding.

The object is to exclude the air and prevent suppuration. Do not change the dressing for four or five days unless there be profuse discharge or bad odor. Resinous ointment, spread on lint sprinkled with turpentine, is another excellent application. If the scald is extensive and on the body, *cold* applications are *not proper*. Keep the air from the wound; this can be done by the dressing already suggested for burns.

Sunstroke.

Take the patient immediately into the shade; place in a semi-

recumbent position, head raised; loosen the clothes about neck and chest; apply immediately ice or cold wet cloths to the head and nape of the neck, changing them frequently. Then douche over head, spine, and chest, from a height of about three feet. Patient to be fanned to produce a cold current of air. Mustard to limbs and sides—stimulants.

Poisons.

In all cases of poisoning, the first step is to give the antidote, if known, and then evacuate the stomach. The last should be effected by a mustard emetic, a tablespoonful of mustard in a cup of water, or a tablespoonful or two of common salt in a tumbler of water. When vomiting has already taken place, copious draughts of warm water or warm mucilaginous drinks, soap and water or oil should be given to keep up the effect till the stomach has been thoroughly cleared.

ANTIDOTES.—*For any of the strong acids:* Common chalk, oil, or soapsuds.

For Arsenic: Magnesia, powdered charcoal, oil, and lime-water.

For Prussic Acid: Cold affusion, ammonia.

For Opium: Keep patient walking, strong coffee, slap with flat ruler, sting with nettles, mustard emetics.

Asphyxia.

Asphyxia arises from carbonic acid, from charcoal fumes, and other gases interfering with the respiration. The face becomes turgid and livid, owing to the accumulation of impure blood. The patient in this case should be placed with the head high, so as to facilitate the flow of blood from the brain, which is congested; the clothes should be taken off, and he should be douched with cold water. Ammonia should be applied to the nose, etc.; the face and body should be sponged with brandy or vinegar and water; friction all over; and artificial respiration if recovery is not evident.

Fever and Ague.

Fever and Ague is always preceded by an ague fit: it has three stages, the cold, hot, and sweating stage.

First, The cold, when teeth chatter.

Second, The hot, with high fever.

Third, The sweating, when moisture appears, and feeling of health returns.

In the event of there being no physician: in cold stage give *hot* drinks, hot foot-bath, hot bottles to sides and limbs.

In hot stage, give cooling drinks, half teaspoonful of sweet spirits of nitre in water every two hours.

During sweating stage, rub with dry towels. In *intermission* give quinine in from two to ten grain doses every three hours, for a few doses: afterward give ten drops of tincture of iron three times a day for a week. Avoid the hot sun and damp evening and morning air. If singing in the ears should come on while taking quinine, the dose should be either lessened or suspended altogether.

To Restore Persons Affected by Cold.

For Frost-bite or Numbness.—Return warmth *gradually* by warm water.

For a Frozen Limb.—Rub with snow, and place in cold water for a time. When sensation returns, place again in cold water; add heat *very gradually* by warm water.

If Apparently Dead or Insensible.—Strip entirely of clothes, and cover body, except mouth and nostrils, with snow or ice, or place in cold water. When body is thawed, dry it, place it in a cold bed; rub with warm hands under the cover; continue this for hours. If life appears, give small injections of camphor and water; put a drop of spirits of camphor on tongue; then rub body with spirits and water, finally with spirits; then give tea, coffee, or brandy and water.

Fainting.

When a person suddenly grows pale and faint, he should be immediately placed full length on the floor, the head being kept low. The face may be dashed with cold water. In this position he will quickly recover—this owing to the head having been placed low so as to facilitate the flow of blood to the brain.

Drunkenness.

Drunkenness in a severe form may cause death by apoplexy; it *is a poisoning* by alcohol. The individual should be placed in a *semi-recumbent* position, with head on one side to favor vomiting,

all the clothing about the neck being freely opened. A douche, from a height, of cold water on face, head, and neck, will probably rouse him. It is difficult to get an emetic to act in this state, yet a tablespoonful of mustard, in half a tumbler of water, had better be given, to excite vomiting. If the respiration becomes embarrassed, artificial respiration should be used, as directed in case of drowning. The preparation called acetate of ammonia (to be had at any apothecary's) taken in ounce doses every half-hour, is said to have a most magical effect in restoring drunken men to sobriety; about three doses ought to suffice.

Bite of a Mad Dog.

In the absence of a surgeon to excise the part, which is the proper treatment, the wound should be quickly washed, sucked, and caustic freely applied to the bottoms of the teeth-punctures. If no caustic be at hand, a hot iron-wire may be used as an actual cautery, or gunpowder may be placed in the wounds and ignited.

Marsh Poison.

When men are employed on detached service in boats, or are otherwise exposed in a swampy region, they should be supplied with quinine to guard them against the marsh poison. Four grains should be administered before starting in the morning and four on their return; but if they should be exposed for twelve hours, or if the exposure be over-night, the quinine should be continued until they return on board, and for fourteen days afterward.

Strength for one dose:

Quinine,	4 grains.
Dilute sulphuric acid,	10 drops.
Water,	2 ounces.
Rum,	1 ounce.

By simple multiplication the above formula may be mixed, for any number of men daily.

Thirst.

Thirst is a fever of the palate, which may be somewhat relieved by other means than drinking fluids.

The mouth is kept moist, and thirst is mitigated by exciting the

saliva to flow. This may be done by chewing something, as a leaf, or by keeping in the mouth a bullet or a pebble.

A spoonful of fat or butter will act on the irritated membranes of the mouth and throat. Life may be prolonged without drinking by keeping the clothes and skin constantly wet, even if the water be salt.

Care must be taken on giving water to persons nearly dead from thirst. Give a little at a time, and keep the whole body wet.

Water.

In all localities where the quality of the water is suspicious, condensed water should, if possible, be used for drinking and cooking purposes. When this is not feasible, the water should be carefully filtered and boiled.

Two barrels, one inside the other, having a space of four or six inches clear all round between them, filled with layers of sand, gravel, and charcoal, form an excellent filter. The inside one, without a bottom, rests on three stones placed in layers of sand, charcoal, and coarse gravel; the water, flowing or being poured into the space between the two barrels, and having thus to force its way through the substances into the inner barrel, becomes purified.

The water should be drawn off by means of a pipe, running through the outer into the inner barrel. Animal charcoal is the best. When, after a time, it ceases to act, it should be removed and well dried. It can then be used again with advantage. It is impossible to use too much of it.

The popular French plan of purifying turbid water (*alumage de l'eau*) simply consists in the addition of a small quantity of alum. It clears the water very rapidly, but merely converts the lime carbonate into sulphate, which remains in solution.

SHIP PAPERS.

The Following are the Papers that may be Expected to be Found on Board a Merchant Vessel, though under Different Nationalities they may Vary.

EVERY Merchant Vessel should carry on board some official voucher for her nationality, issued by the authorities of the country to which she belongs.

The official voucher of a vessel which belongs to a country possessing a register of its mercantile marine, is a certificate of her registry; in other cases its form varies and passes under different names—"passport," "sea-brief," etc.

THE CERTIFICATE OF REGISTRY is a document signed by the registrar of the port to which the vessel belongs, and usually specifies the name of the vessel and of the port to which she belongs; her tonnage, etc.; the name of her master; particulars as to her origin; the names and description of her registered owners.

THE PASSPORT purports to be a requisition on the part of a sovereign power or state to suffer the vessel to pass freely with her company, passengers, goods, and merchandise without any hindrance, seizure, or molestation, as being owned by citizens or subjects of such state. It usually contains the name and residence of the master; the name, description, and destination of the vessel.

THE SEA-LETTER, OR SEA-BRIEF, is issued by the civil authorities of the port from which the vessel is fitted out; it is the document which entitles the master to sail under the flag and pass of the nation to which he belongs; and it also specifies the nature and quantity of the cargo, its ownership and destination.

THE CHARTER-PARTY is the written contract by which a vessel is let, in whole or in part; the person hiring being called the charterer. It is executed by the owner or master, and by the charterer. It usually specifies (among other things) the name of the master, the name and description of the vessel, the port where she was lying at the time of the charter, the name and residence of the charterer, the character of the cargo to be put on board, the port of loading, the port of delivery, and the freight which is to be paid.

The charter-party is almost invariably on board a vessel which has been chartered.

THE OFFICIAL LOG-BOOK is the log-book which the master is compelled to keep in the form prescribed in the municipal law of the country to which the vessel belongs.

THE SHIP'S LOG is the log kept by the master for the information of the owners of the vessel.

THE BUILDER'S CONTRACT is to be expected on board a vessel which has not changed hands since she was built. It is not a necessary document, but it sometimes serves, in the absence of the passport,

or sea-letter, or certificate of registry, to verify the nationality of a vessel.

THE BILL OF SALE is the instrument by which a vessel is transferred to a purchaser. It should be required whenever a sale of a vessel is alleged to have been made either during a war or just previous to its commencement, and if there is any reason to suspect that the vessel is liable to detention, either as an enemy's vessel or as an American or allied vessel trading with the enemy.

BILLS OF LADING usually accompany each lot of goods.

A bill of lading on board is a duplicate of the document given by the master to the shipper of goods on the occasion of the shipment. It specifies the name of the shipper, the date and place of the shipment, the name and destination of the vessel, the description, quantity, and destination of the goods, and the freights which are to be paid.

THE INVOICES should always accompany the cargo; they contain the particulars and prices of each parcel of goods, with the amount of the freight, duties, and other charges thereon, and specify the name and address of the shippers and consignees.

THE MANIFEST is a list of the vessel's cargo, containing the mark and number of each separate package, the names of the shippers and consignees; a specification of the quantity of goods contained in each package, as rum, sugar, etc., and also an account of the freight corresponding with the bills of lading.

The manifest is usually signed by the ship-broker who clears the vessel out at the Custom-House, and by the master.

THE CLEARANCE is a certificate of the Custom-House authorities of the last port from which the vessel came, to show that the Custom duties have been paid. The clearance specifies the cargo and its destination.

THE MUSTER-ROLL contains the name, age, quality, place of residence, and place of birth of every person of the vessel's company.

SHIPPING ARTICLES are the agreement for the hiring of seamen. They should be signed by every seaman on board, and should describe accurately the voyage and the terms for each seaman shipped.

THE BILL OF HEALTH is a certificate that the vessel comes from a place where no contagious distemper prevails, and that none of her crew at the time of her departure were infected with a contagious disease.

FOREIGN SEA TERMS.

Sails.

ENGLISH.	FRENCH.	ITALIAN.	SPANISH.
Sail.	Voile.	Vela.	Vela.
Main-sail.	Grande voile.	Vela di maestra.	Vela mayor.
Main top-sail.	Grand hunier.	Gabbia.	Gavia.
Main top-gallant sail.	Grand perroquet.	Gran velaccio.	Juanete mayor.
Main-royal.	Grand cacatois.	Contro velaccio.	Sobre mayor.
Fore-sail.	Misaine.	Trinchetto.	Sobre trinquete.
Fore top-sail.	Petit hunier.	Parrochetto.	Sobre velacho.
Fore top-gallant sail.	Petit perroquet.	Piccolo velaccio o velaccino.	Juanete de proa.
Fore-royal.	Petit cacatois.	Contro velaccino.	Sobre de proa.
Mizzen top-sail.	Perroquet de fougue.	Contra mezzana.	Sobre mesana.
Mizzen top-gallant sail.	Perruche.	Belvedere.	Perico.
Mizzen-royal.	Cacatois d'artimon.	Contro belvedere.	Sobre perico.
Fore top-mast stay-sail.	Voile d'étai du petit hunier.	Trinchettina.	Vela de estay de velacho.
Gaff top-sail.	Voile à corne.	Vela di pico.	Cangrejo.
Jib.	Foc.	Fiocco.	Foque.
Flying-jib.	Clinfoc.	Controfiocco.	Petifoque.
Try-sail.	Brigantine.	Brigantina.	Vela de estay.
Spanker.	Voile à gui.	Randa.	Cangreja.
Lower studding-sail.	Bonnette basse.	Scopa mare.	Rastrera.
Top-mast studding-sail.	Bonnette d'hune.	Coltellaccio di gabbia.	Alas de gavia.
Top-gallant studding-sail.	Bonnette de perroquet.	Coltellaccio di velaccio.	Alas de juanete.

Foreign Sea Terms.—*Continued.*

Masts, Yards, &c.

ENGLISH.	FRENCH.	ITALIAN.	SPANISH.
Mast.	Mât.	Albero.	Palo.
Yard.	Vergue	Pennone.	Vergo.
Boom.	Bome ou gui.	Boma.	Botavara.
Main-mast.	Grand mât.	Albero d'maestra.	Palo mayor.
Fore-mast.	Mât de misaine.	Albero di trinchetto.	Palo de trinquete.
Mizzen mast.	Mât d'artimon.	Albero di mezzana.	Palo de mesana.
Bowsprit.	Beaupré.	Bompresso.	Bauprés.
Top-mast.	Mât d'hune.	Albero di gabbia.	Mastelero.
Top-gallant mast.	Mât de perroquet.	Albero di velaccio.	Mastelero de juanete.
Lower yard.	Basse vergue.	Pennone maggiore.	Verga mayor; Verga de trinquete.
Top-sail yard.	Vergue d'hune.	Pennone di gabbia.	Verga de gabia.
Top-gallant yard.	Vergue de perroquet.	Pennone di velaccio.	Verga de juanete.
Royal-yard.	Vergue de cacatois.	Pennone di contro.	Verga de sobre juanete.
Top.	Hune.	Coffa.	Cofa.
Cross-tree.	Barres de perroquet.	Crocette.	Crucetas.
Cap.	Chouquet.	Testa di moro.	Tamborete.
Truck.	Pomme du mât.	Galetta.	Perilla; Laletta.
Jib-boom.	Baton de foc.	Asta di fiocco.	Botalon de foque.

Foreign Sea Terms.—*Continued.*

Miscellaneous.

ENGLISH.	FRENCH.	ITALIAN.	SPANISH.
Ship.	Vaisseau ; Bâtiment.	Nave ; Bastimento.	Buque.
Deck.	Pont.	Coperta.	Cubierta.
Hold.	Cale.	Stiva.	Bodega.
Cabin.	Chambre.	Camera.	Cámara.
Windlass.	Guindeau.	Mulinello.	Molinete.
Capstan.	Cabestan.	Argano.	Cabrestante.
Bitts.	Bittes.	Bitte.	Bitas.
Compass.	Boussole, Compas.	Bussola.	Aguja, compás.
Helm.	Barre.	Timone.	Timon.
Anchor.	Ancre.	Ancora.	Ancla.
Cable.	Cable.	Gomena.	Cable.
Forward.	À l'avant.	A prora.	A proa.
Aft.	À l'arrière.	A poppa.	A lopa.
Fore and aft.	À l'avant et à l'arrière.	Poppa a prora.	Abarloado; Prolongado.
Athwart.	Par le travers.	Al traverso.	Por el través.
Hawser.	Grelin.	Gherlino.	Guindaleza.
Starboard	Tribord.	Dritta.	Estribor.
Port.	Babord.	Sinistra.	Babor.
Below.	En bas.	Abasso.	Abajo.
Aloft.	En haut.	Ariva.	Arriba.
Avast.	Tenezbon.	Basta.	Forte!
Shrouds.	Haubans.	Sartie.	Obenques.
Stay.	Etai.	Straglio.	Estay.
Back-stays.	Galhaubans.	Patarazzi.	Brandales ; Volantes.
Bobstay.	Sous barbe.	Briglia.	Barbiquejo.
Lanyards.	Rides.	Ride.	Acolladores.
Tackle.	Palan.	Paranco.	Aparejo.

Foreign Sea Terms.—*Continued.*

English.	French.	Italian.	Spanish.
Braces.	Bras.	Bracci.	Brazas.
Tack.	Amure.	Mura.	Amura.
Sheet.	Écoute.	Scotta.	Escota; Escotin.
Halyards.	Drisse.	Drizza.	Driza.
Down-haul.	Carguebas.	Caricabasso.	Cargadera.
Clew-lines.	Cargues points.	Controscotte.	Chafaldete.
Bunt-lines.	Cargues fonds.	Mezzi.	Brioles.
Brails.	Cargues de voile	Serrapennoni.	Candalizas.
Reef-tackle.	Palanquin de ris.	Paranchini di terzarnolo.	Amante de rizos
Bow-line.	Bouline.	Boline.	Bolina.
Gasket.	Raban de ferlage.	Matafioni.	Tomador.
Crew.	Equipage.	Equipaggio.	Tripulacion.
Boatswain.	Maitre d'equipage.	Nostromo.	Contramaestre.
Sail-maker.	Voilier.	Veliere.	Velero.
Carpenter.	Charpentier.	Falegname.	Carpintero.
Steward.	Commis aux vivres.	Dispensiere.	Despensero.
Cook.	Cuisinier.	Cuoco.	Cocinero.
Seaman.	Matelot.	Marinaro.	Marinero.
Belay.	Amarrez.	Date volta.	Amarra!
Let go.	Larguez.	Larga.	Larga!
Hoist away.	Hissez.	Issa.	Iza!
Lower away.	Amenez.	Amaina.	Arria!
Haul.	Halez.	Ala.	Hala!
Handsomely.	En douceur.	Poco a poco.	Poco á poco.
Hold on.	Tenez.	Agguanta.	Aquanta!
Heave away.	Virez.	Virate.	Vira!
Slack.	Filez.	Filate.	Arria!
Bear a hand.	Vite.	Presto.	Pronto! Volado!
Boat.	Báteau.	Batello.	Bote.

Foreign Sea Terms.—*Continued.*

ENGLISH.	FRENCH.	ITALIAN.	SPANISH.
Oar.	Aviron.	Remo.	Remo.
Clear.	Clair.	Chiaro.	Clara.
Foul.	Embrouillé.	Impegnato.	Enredado.
Windward.	Au vent.	Sopravento.	Barlovento.
Leeward.	Sous le vent.	Sottovento.	Sotavento.
Catch hold.	Attrappez.	Arresta.	Agarra!
Look out.	Vigie.	Guardate.	Vigia—Tope.
All right.	Tout droit.	Va bene.	Benno; Esta bien, etc.

FOREIGN SEA PHRASES.

Heave away the windlass.	Virez au cabestan.	Vira l'argano.	Vira cabrestante.
Sheet home the top-sails.	Bordez les huniers.	Alate le scotte delle gabbie.	Caza á beser los escoti nes de las gavias.
Hoist the top-sails.	Hissez les huniers.	Issate le gabbie.	Iza gavias.
Hoist the top-gallant sails.	Hissez les perroquets.	Issate i velacci.	Iza juanetes.
The anchor is a-weigh.	L'ancre est dérapeé.	L'ancora ha lasciato.	El ancla ha largado.
Hoist the jib.	Hissez le foc.	Issate il fioco.	Iza foque.
Fill the head sails.	Brassez plein les voile de l'avant	Fate portar le vele di proa.	Braza en viento las velas de proa.
Set the main-sail.	Mettez la grande voile.	Spiegate la vela di meastra.	Amura mayor.
Ready about.	Pare á virer.	Pronto a virare.	Alista á virar.
Helm's a-lee.	Adieu va.	Sotto la barra.	Orzo á la banda.

Foreign Sea Phrases.—*Continued.*

ENGLISH.	FRENCH.	ITALIAN.	SPANISH.
Raise tacks and sheets.	Lève les lofs.	Smura.	Levanta puños sobre bolinas.
Main-sail haul.	Changez derrière.	Tiro-molla a poppa.	Cambia al medio
Let go and haul.	Changez devant	Tira-molla a prora	Descarga á proa.
Brace sharp up.	Bràs et boulimes (derrière ou devant.)	Bracciate bene a sotovento.	Braza bien á cenir.
Square the yards.	Brassez carré.	Bracciate in croce.	Braza en cruz.
Hard up the helm.	La barre au vent	Barra al vento.	Ando todo; Todo de arribada
Steady the helm.	Comme cela!	Barra in mezzo.	Caña á la via.
Up main-sail.	Carguez la grande voile.	Imbrogliate la maestra.	Carga mayor.
Round in the weather-braces	Appuyez les bras du vent.	Alate i bracci di sopravento.	Afirma á barlovento.
Haul down the jib.	Halez bas le foc.	Alabasso il fiocco	Arria foque.
Up fore-sail.	Carguez la misaine.	Imbrogliate il trinchetto.	Carga trinquete
Back the main top-sail.	Brassez a culer le grande hunier.	Bracciate in faccia la gabbie.	Poner la gavia por delante; Poner en facha la gavia.
Let go the anchor.	Mouillez.	Date fondo all'ancora.	Fondo an ancla.
Clew up the top-sails.	Carguez les huniers.	Imbrogliate le gabbie.	Carga gavias.
Brail the spanker up.	Carguez l'artimon.	Imbrogliate la randa.	Carga cangreja.
Pay out the cable.	Filez de la chaine.	Filate la gomena.	Fila cadens; Fila cabie; Arria cadena.

Foreign Sea Phrases.—*Continued.*

ENGLISH.	FRENCH.	ITALIAN.	SPANISH.
Furl the sails.	Serrez les voiles	Serrate le vele.	Aferra el velámen
Hoist the ensign	Hissez le pavillon.	Alzate la bàndiera.	Iza la bandera.
Coil the ropes up.	Lovez les manœuvres.	Raccogliere la manovra.	Aduja los cablos
Right the helm.	Droit la barre.	Il timone alla via	Caña á la via.
Ship ahoy!	Ho du navire!	Olā bastimento.	Ah del buque.
What ship is that?	Quel est le nom du navire?	Come si chiama il bastimento?	Como se llama el buque.
Where are you from?	D'ou venez vous?	D'onde venite?	De dónde viene?
Where are you bound to?	Où allez vous?	Dove andate?	Adónde vā?
How many days out?	Combien de jours en route?	Quanto tempo in viaggio.	Cuántos dias de navegacion?
Please to report me.	Dites que vous m'avez rencontré	Annunziatemi.	Diga qué noticias traer.
Ship's papers.	Papiers du bord	Documenti del bastimento.	Los papelas del buque.
Register.	Contrât de construction.	Lettere di costruzione.	Registro de construccion.
Bills of lading.	Connaissements	Conoscimenti.	Conocimientos.
Manifest.	Manifest.	Manifesto.	Manifiesto.
Bill of health.	La patente de santè.	Certificato di sanità.	Patente de sanidad.
Log-book.	Journal de bord.	Cuadarmo di chiasnola.	Cuaderno de bitácora.

INDEX.